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EIGHTH ANNUAL REPORT

... OF THE ...

AGRICULTURAL COLLEGE

... OF THE ...

UNIVERSITY OF WYOMING

... AND OF THE ...

WYOMING AGRICULTURAL EXPERIMENT STATION

FOR THE FISCAL YEAR ENDING JUNE 30, 1898.

LARAMIE, WYO.
THE REPUBLICAN BOOK AND JOB PRINT.
1898.

EIGHTH ANNUAL REPORT

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AGRICULTURAL EXPERIMENT STATION

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LARAMIE, WYO.
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1898.

University of Wyoming.

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LETTER OF TRANSMITTAL.

To His Excellency,
Hon. Wm. A. Richards,
Governor of Wyoming.

Sir:—I have the honor to submit herewith the Eighth Annual Report of the Agricultural College and the Agricultural Experiment Station of Wyoming. This report is made in accordance with Sections 3 of Acts of Congress of August 30, 1890, and March 2, 1887, and covers the work of the College and Station from July 1, 1897, to July 1, 1898.

Copies will be sent also to all agricultural colleges, to the Secretary of the Treasury, to the Secretary of the Interior, and to the Secretary of Agriculture.

Trusting that the statements contained in the report will prove satisfactory to your Excellency, I remain,

Most respectfully yours,

Frank Pierrepont Graves

President and Director.

Laramie, Wyoming,
June 30, 1898.

Faculty of the College of Agriculture.

FRANK P. GRAVES, Ph. D., LL. D., President,
Professor of Political Science.
BURT C. BUFFUM M. S.,
Professor of Agriculture and Horticulture.
AVEN NELSON, M. S., M. A.,
Professor of Biology.
HENRY MERZ, M. A.,
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Professor of History and Modern Languages.
CHARLES A. VARNUM, Capt. Seventh Cavalry, U. S. A.,
Professor of Military Science and Tactics and Assistant Professor of Mathematics.
CHARLES B. RIDGAWAY, M. A.,
Professor of Physics and Mathematics.
LOUISE H. MOREY, B. A.,
Professor of English.
WILLIAM F. GILKISON, B. S.,
Associate Professor of Drawing and Industrials.
WILLIAM H. REED,
Assistant in Geology and Paleontology.

EIGHTH ANNUAL REPORT.

. . . OF THE . . .

College of Agriculture of the University of Wyoming.

I hereby submit the eighth annual report of the College of Agriculture of Wyoming, in compliance with enactment of Congress. Owing to the change of date due to the suggestion of the Office of Experiment Stations, Department of Agriculture, all work of the fiscal year of 1897-98 is included in this report.

INCEPTION OF THE COLLEGE.

The first president of the University of Wyoming, when constructing the various courses of the institution, in accordance with the act of incorporation, planned for distinct schools of agriculture and mechanic arts. These departments did not obtain much growth until 1891. On the 10th of January of that year they were organized into separate colleges by an act of the Legislature of Wyoming, which vested the control of the appropriations from the Morrill Act of Congress in the Board of Trustees of the State University. The Morrill Act, approved August 30, 1890, was intended to grant an endowment for agricultural and mechanical colleges in addition to that obtained by a land grant on July 2, 1862.

PRESENT MANAGEMENT AND COURSE.

The Board of Trustees, whose names appear on a preceding page, remain the same as at the time of the last report. The Faculty of the College, with the position held by each member, appears on the same page with the Trustees. Wherever a consolidation of classes has been possible, the same professor of a subject has been employed as in the College of Liberal Arts. Thus considerable expense has been saved to the state and an economical management effected.

The various courses in agriculture and mechanical engineering have been appended to this part of the report, and will be found to present as high a standard as those of any similar institution in the country. The model offered by the Committee on Courses of the American Association of Agricultural Colleges and Experiment Stations has been closely followed.

ADDITIONAL EQUIPMENT.

A brief examination of the Treasurer's Report which is appended to this statement will show that the expenditures were this year larger than ever before. Most of this increased expenditure went for new apparatus and better facilities in the various laboratories. The accession of books is very marked, as shown by the statement of the librarian, and the amount spent in this direction will from year to year be rather increased than diminished. Numerous machines and a tool-room with a connecting dumb-waiter have been added to the department of mechanical engineering.

A commodious wing for increasing the room to be devoted to foundry work was built on the Mechanical Building during the summer of 1897. The Greenhouse was also enlarged by the addition of a wing of rather greater area than the main portion of the building. The general furnishings of the Main Building have been also greatly improved.

ATTENDANCE.

Notwithstanding the growth of about fifty percent last year, the increased attendance in all departments of the University this year has been great. The institution as a whole has grown nearly twenty percent. Two such remarkable years have so claimed the attention of the public that people have come to feel the full value of the University and to be more willing to patronize a home institution. The growth next year probably will be still larger.

DISCIPLINE.

The conduct of the students has been excellent this year. The influx of so many pupils from outside of Laramie has brought about a loyalty to the University as a State institution that has been manifest in the behavior of all the students.

The change in the principalship of the Preparatory School has also had much to do with the improvement in order. The younger students naturally are more prone to make trouble and always have need of a firm but kind hand to rule them.

A GREAT NEED.

It is very evident that, with the increase of students during the last few years, the erection of a Science Hall ought not to be delayed another year. If it is, the departments of chemistry, physics, geology, biology, and mechanical engineering are bound to suffer seriously. The legislature should not refuse to make an appropriation for a building that has been so long needed and would be of so much value to the state.

Departmental Statements.

The following is a detailed report of each department of the College of Agriculture:

POLITICAL SCIENCE.

This department includes civics, public law, political economy, and sociology. Its aim has been to cultivate independent thought and foster intelligent citizenship. After the origin and growth of each subject has been investigated, and the general principles have been acquired, the student is required to apply the principles thus obtained to leading problems of the present day. Debates, public and private, form an important feature of the courses. The following subjects are offered:

I. *Constitutional Law.* Cooley; Black. Examination of cases; lectures; debates. [Elective for agricultural seniors.]

II. *International Law.* Walker; Gallaudet; Woolsey; Snow's Cases. Lectures; debates; theses. [Elective for agricultural seniors.]

III. *Political Economy.* Ely's Introduction; Walker, Marshal; Gregory. Lectures; debates; theses. [Required of agricultural and mechanical seniors.]

IV. *Comparative Government.* Wilson's The State; Wenzel's Comparative View of Government; Bagehot's English Constitution; Helie's Les Constitutions de France; Nicolson's Sketch of the German Constitution; Bryce's American Commonwealth. Lectures; theses. [Elective for seniors.]

SOCIAL SCIENCE.

The aim of this department is to familiarize students with the history of social development and to encourage investigation of the principles on which social progress depends. After a thorough grounding in the fundamental facts, the student is expected to observe the social phenomena about him and to study the various problems in an independent manner. Inasmuch as sociology is a science of recent birth and its theories are constantly expanding, much of the class-work consists of lectures and theses. The following subjects are offered:

I. *Principles of Sociology.* Small and Vincent; Giddings; Kidd's Social Evolution. Lectures; debates; theses. [Elective for agricultural seniors.]

II. *Social Problems.* Study of crime, suicide, insanity, pauperism, charities, temperance, socialism, education, etc. Discussion; theses. [Elective for agricultural seniors who have taken I and Philosophy IV.]

III. *Social Philosophy.* Lectures on social theories, old and new, and on the aims of society. Discussions; theses. [Elective for agricultural seniors who have taken I and II.]

PHILOSOPHY.

The work of this department is intended to furnish an acquaintance with philosophic thought, to afford a training in the methods of investigating philosophic phenomena, and to imbue the student with the latest methods of education. Special attention is given to physiological psychology. The work in this subject is illustrated by charts and models of the brain and sense organs and by the introduction of various experiments. In teaching logic more time than formerly is given to inductive reasoning, as a perfect knowledge of this form is especially helpful to scientific students and to those intending to do research work in philosophy.

I. *Psychology.* James's Briefer Psychology, supplemented by outside reading and lectures. A consideration of the structure and functions of the nervous system and sense organs, of consciousness, attention, memory, emotions, movements, habits and their formation, and the pathological conditions of the mind. [Required of agricultural juniors.]

II. *Physiological Psychology.* James. Ladd. Observation and experiments; investigation of special topics. [Elective for agricultural seniors.]

III. *Logic.* Jevons-Hill's Elements of Logic as text, with Fowler, Bain, Sidgwick, and others for reference. Treatment of the proposition, immediate and mediate inference, the hypothesis, arguments, and fallacies. Special attention to the principles and methods of induction. [Elective for agricultural seniors.]

IV. *Ethics.* Bowne's Principles of Ethics, supplemented by discussions and assigned readings from Spencer, Bain, Seth, and others. Examination of the principal theories and of special topics, such as the formation of the ethical ideal, the duties of the individual, of the family, and of society. [Elective for agricultural seniors.]

BIOLOGY.

The department of biology as at present organized includes botany, zoology and physiology.

Even in the introductory courses laboratory work is made a prominent feature in order that from the first students may become self-reliant.

The equipment of the department has been adequate to the demands made upon it, and as new necessities arise in connection with the several courses, they will be supplied as far as possible from the resources at command.

One of the two rooms of the department is a convenient lecture room having, among its other equipments, a lantern with microscope attachment. This enables the instructor to illustrate on the screen by both lantern and microscope slides the subject under discussion.

The laboratory is large and well lighted, and is furnished with working tables and desks. The following subjects are offered:

BOTANY.

I, II, III. *General.* The purpose of this introductory course is to give a general view of the entire field. The work progresses from the simplest plants to the more specialized forms. The first and second terms are devoted to the morphology and physiology of plants, and the third term to the ecology and classification of phanerogams. [Required of agricultural freshmen.]

IV, V. *Histology and Physiology.* A course in histology and experimental physiology of the higher plants, together with a consideration of some of the special problems of plant reproduction and morphology. [Elective for agricultural seniors.]

VI. *Mycology.* Fungi in general, but with special attention paid to those of economic importance. [Elective for agricultural seniors.]

ZOOLOGY.

I, II, III. *General.* The aim is to acquaint the student with the main facts of animal structure, physiology, and classification by means of lectures, laboratory work on typical animal forms, and prescribed reading. It is a prerequisite for the other courses in Zoology. [Required of agricultural sophomores.]

IV, V. *Comparative Anatomy of Vertebrates.* A study of the principal problems connected with the successive modifications of the different organs in the several classes of animals. [Elective for all who have taken I, II, and III.]

VI. *Microscopical Anatomy.* Microscopical technique, methods of investigation, and the preparation of sections of normal vertebrate tissues. [Elective for agricultural seniors.]

PHYSIOLOGY.

I. *Advanced Physiology.* This course assumes on the part of the student such general knowledge of the human body as is provided in the grammar grades of our best public schools. The course aims to review the more important subjects to consider the problems of hygiene that are of special interest to all students. [Required of preparatory agricultural students.]

AGRICULTURE.

The instruction in agriculture aims to give the student the greatest possible knowledge of the science of agricultural practice in the time given. The larger part of the instruction is by lectures. Where text-books are used, they are supplemented by lectures, keeping the student abreast of the times.

Up to the senior year, as often as the other work will permit, students are required to work in the greenhouse or upon the agricultural grounds or experiment farm two hours each afternoon. As far as possible, the work is made to illustrate the branch being taught. The agricultural museum furnishes material with which to illustrate the study of farm crops and the agricultural productions of the world.

In the work upon the farm and the instruction in the class-room, the methods and results of the Experiment Station are always before the student. These will afford him much general information regarding the practice of agriculture in this region, and will give him an insight into the way by which important facts are deduced from the mass of daily observations and notes. The following subjects are required:

I. *History of Agriculture.* Taught by lectures and reference books, such as Goss' Principles of Plant Culture, and Johnson's How Plants Grow, and How Plants Feed. A brief outline of the history of agriculture, followed by a thorough course in the principles of plant cultivation and growth. [Required of agricultural sophomores.]

II. *Soils, Tillage, and Fertilizers.* Taught by lectures and reference books, such as King's The Soil, and Storer's Agriculture. [Required of agricultural sophomores.]

III. *Farm Crops.* Lectures. Planting, irrigating, harvesting, and marketing; laying out and improving farms; farm management and farm accounts. The students' practice will include setting up and running farm machinery, planting and irrigating crops properly. [Required of agricultural sophomores.]

IV, V. *Breeds of Live Stock.* Curtiss' Breeds of Live Stock, Warfield's Cattle Breeding, Miles' Stock Breeding, supplemented by lectures and practice in judging by scale of points. [Required of agricultural juniors.]

VI. *Stock Feeding and Dairy Management.* Armsby's Cattle Feeding, Henry's Feeds and Feeding, and lectures. [Required of agricultural juniors.]

HORTICULTURE.

The instruction in this department aims to give the student a good general foundation in the science of gardening, plant cultivation, fruit raising, landscape and ornamental gardening. During the Spring term of one year, two hours of laboratory work each week in the multiplication of plants, grafting, budding, and making cuttings are required. The following subjects are offered:

I. *Plant Forcing.* Study of green-houses and hot-beds, and of the cultivation and propagation of vegetables and small fruits. Lectures. [Required of agricultural juniors.]

II. *Pomology.* Pruning, grafting, budding, cuttings, and orcharding. Lectures. [Required of agricultural juniors.]

III. *Landscape and Ornamental Gardening.* Lectures. [Elective for agricultural seniors.]

IV. *Thesis Work.* Pollination, cross fertilization, variation, or other advanced subject. [Elective for agricultural seniors.]

ENTOMOLOGY.

This department aims to give the student an insight into insect life, and afford some knowledge of economic entomology through the study of injurious insects and the means for their extermination. The following subjects are required:

I. *Elementary.* Packard's Entomology, with Comstock for reference. Lectures. [Required of agricultural juniors.]

II. *Economic Entomology.* Smith's Economic Entomology, supplemented by lectures. [Required of agricultural juniors.]

IRRIGATION.

The object of this department is to give a general idea of the principles of irrigation practice and water measurement.

I. *Principles.* Effects of water on soil and crops, and measurement of water. Lectures, reference reading, and practical work. [Required of agricultural juniors.]

CHEMISTRY.

The work of all courses in the department of chemistry is experimental and inductive so far as consistent with the acquirement of the necessary amount of general information. Students are from the first encouraged to work independently on lines of investigation in which they are specially interested.

The department of chemistry occupies four rooms in the south end of the Main Building. One room contains the analytical balances and the chemical reference library, the second is devoted to the experimental work of the Wyoming Agricultural Experiment Station, the third is a lecture room, and the fourth and largest room is fitted up for the classes in qualitative and quantitative analysis. The department is well equipped with apparatus for research and analytical work in organic and inorganic chemistry. The following subjects are open:

I, II. *Elementary.* Freer, and Storer and Lindsay. The aim of this course is to give students a knowledge of the laws of chemical change, a practical familiarity with the principal elements and compounds, and skill in the manipulation of apparatus. [Required of agricultural and mechanical sophomores.]

III. *Qualitative Analysis.* Caldwell's Qualitative Analysis. Students will acquire the ability to detect the ordinary acids and bases in any substance. [Required of agricultural and mechanical sophomores.]

IV. *Quantitative Analysis.* Caldwell and Fresenius. Twenty simple gravimetric and volumetric determinations. [Elective for students who have taken III.]

VI. *Inorganic Preparations.* Erdman's Anleitung zur Darstellung chemischer Präparate. Preparation of a number of difficult compounds and elements. [Open to students who have taken III; spring term; laboratory work ten hours a week.]

VII. *Organic Chemistry.* Remsen's Organic Chemistry. Lectures and recitations on the compounds of carbon. [Required of agricultural juniors; fall term; five times a week.]

VIII. *Organic Preparations.* Gatterman; practical methods in organic chemistry. [Open to students who have taken VII; winter term; laboratory work ten hours a week.]

XI. *Agricultural Chemistry.* The chemistry of plant growth, and the application of chemical principles to practical agriculture with special reference to the problems of the arid region. [Required of agricultural juniors; winter term; lectures three hours and laboratory work four hours a week.]

XII. *Applied Chemistry.* Lectures on chemical processes and manufactures not included in metallurgy, and on methods of analysis and control. Most attention is paid to subjects of practical importance in Wyoming; such as petroleum and its products; coal, gas, and coke; building stone and cements; alkalies and acids; beet sugar; glass; air and water supply. [Required of mechanical juniors.]

GEOLOGY.

Most of the instruction in this department is given by lectures, but text-books are used for reference together with the latest geological reports.

The location of the Agricultural College is exceptionally advantageous for the study of geology. Only a few miles east the Laramie mountains rise nearly 2,000 feet above the campus, while to the westward the Medicine Bow mountains rise 5,000 feet. Both of these mountain ranges are mineralized, and mining has been carried on for many years. They furnish rich fields for the student of structural and dynamical geology, as well as for those who wish to study almost new archean exposures. Flanking these ranges are paleozoic, mesozoic, and cenozoic rocks that have been exposed by the mountain making and subsequent erosion, so that a student may easily make himself familiar with the entire series of Rocky Mountain sedimentary rocks.

The working collections of rocks and fossils in the department are not large, but well selected and are increasing in size very rapidly. The collection of mesozoic invertebrates is very complete, and the collection of jurassic vertebrates is the second in size in the United States. To those who wish to study economic geology special inducements can be offered, since ores of economic value are numerous, and are only a short distance away. The plains are also well supplied with mines of coal and deposits of clay, gypsum, and building stones.

The following list of books is used for reference and text work in this department: LeConte, Dana, Geikie, Kayser-Lake, Lapparent, Tarr, Zittel, and Nicholson and Lydekker. The following subjects are offered:

I. *Dynamical and Structural.* Geological forces, conditions in which stratified rocks are found, and general topography. Lectures; LeConte and Dana as texts. [Required of agricultural juniors.]

II. *Mineralogical.* Elementary study of mineralogy, in which a student is required to determine fifty species of common minerals with the blow-pipe. Lectures; Crosby and Brush as texts. [Required of agricultural juniors.]

III. *Historical.* Study of fossilized life associated with stratified rocks, and methods of determining formations from associated fossil life. Lectures; LeConte and Dana as texts. [Required of agricultural juniors.]

IV. *Economic.* Study of the minerals of economic importance and methods of preparing them for the market. Lectures; Kemp and Tarr as texts. [Elective for agricultural seniors.]

V. *Paleontological.* Elementary course in paleontology. Lectures; Nicholson and Lydekker as text. [Elective for agricultural seniors.]

VI. *Advanced.* Course arranged to suit the needs of students. One week in the field. [Elective for agricultural seniors.]

HISTORY.

The purpose of the department of history is to create a taste for historical reading and give the ability to comprehend rightly the events of the times by applying the experience of the past to the conditions and problems of today. The aim is not the accumulation of a mass of facts and dates, but the acquisition of a right comprehension of great historical events.

Text-books are used, especially in the preparatory classes; but the study of the assigned lessons is supplemented by reading different authorities on the same subject and by lectures. The historical library has been greatly enlarged during the past year and is at the disposal of the students in this department. The following courses are offered:

I. *England.* Montgomery's English History. [Required of preparatory students.]

II, III. *Mediaeval and Modern.* Myer's Mediaeval and Modern History. [Required of preparatory students.]

IV. *Greece.* Smith's Shorter History of Greece. (Brownson's Revision); Guerber's Mythology. [Elective for agricultural seniors.]

V. *Rome.* Allen's History of Rome. [Elective for agricultural seniors.]

VI, VII, VIII. *Middle Ages.* Thatcher and Schwill. Lectures and supplementray reading. [Elective for agricultural seniors.]

ENGLISH.

The aim of the preparatory work in this department is to teach the student to understand and use the English language correctly and to cultivate in him a taste for the best literature. A thorough mastery of English grammar is required before entrance to the Preparatory Year.

The student's work in literature is made to furnish the occasion as well as the material for the preparation of essays. These essays are subject to criticism both in the class and with the individual writers.

The formal study of rhetoric is designed to ground the student in the principles of English composition and to cultivate his literary sense by analytical study.

The work in oratory is of a practical character. An effort is made to secure reading that shall be intelligent, natural and forcible, and to develop spontaneous expression from the mental side. The student meets the instructor personally for rehearsal and criticism.

The following subjects are open:

I, II, III. *Elementary*. Lockwood's Lessons in English. Selections from the following American authors are read: Longfellow, Irving, Hawthorne, Bryant, Holmes, Lowell, Whittier. Essays and recitations, based upon the text-book and reading. [Required of preparatory students.]

VII, VIII, IX. *Principles of Literature*. Careful reading of the following works: Milton's Paradise Lost, Books I and II; Pope's Iliad, Books I and XXII; The Sir Roger de Coverly Papers in The Spectator; Goldsmith's Vicar of Wakefield; Coleridge's Ancient Mariner; Southey's Life of Nelson; Carlyle's Essay on Burns; Lowell's Vision of Sir Launfal; Hawthorne's House of Seven Gables. [Required of mechanical sophomores and agricultural freshmen.]

X, XI, XII. *History of Literature*. History of English and American literature. Selected reading; composition; recitations. [Required of mechanical juniors.]

XIII, XIV, XV. *English Masterpieces.* Critical study of the masterpieces of English literature; especially, selections from Milton, Dryden, Pope, Thomson, Johnson, Gray, Goldsmith, Cowper, Burns, Coleridge, Byron, Keats, Shelley, Wordsworth, Macaulay, Matthew Arnold, Browning, Tennyson. [Required of agricultural sophomores.]

XIX, XX, XXI. *Oratory.* Study of selections from great English and American orators. Principles of oratory exemplified in practice. [Required of seniors.]

MATHEMATICS.

The instruction in mathematics aims to develop the powers of mental concentration, to give facility in attacking original problems, and ability to recognize the difference between logical proof and presumptive evidence, and to form in the student the habit of expressing his ideas in concise mathematical language.

All fundamental concepts are presented in as many different forms as possible, with fullness of explanation and variety of illustration, so that the student may thoroughly understand all the principles involved.

The following subjects are required:

I, II, III, IV. *Algebra.* Wentworth, Wells, Taylor, or Charles Smith. Fundamental operations. Fractions and fractional equations, simultaneous equations of the first degree. Problems involving two unknown numbers, simple indeterminate equations, involution and evolution. Radical and imaginary expressions, quadratic equations, ratio and proportion. [Required of preparatory students and freshmen.]

V, VI. *Plane Geometry.* Wells, Wentworth, Chauvenet, or Beman and Smith. Much of the time is devoted to solving original propositions, and if time permits, some of the modern methods and the geometrical theory of proportion will be taught. [Required of freshmen.]

VII. *Advanced Algebra.* Wells' College Algebra. Progressions, binomial theorem, convergent and divergent series, undetermined coefficients, logarithms, permutations and combinations, summation of series, determinants, theory of equations, solution of higher equations. [Required of mechanical sophomores.]

IX. *Trigonometry.* Wells' New Trigonometry. The development of the general formulae and their application to the solution of triangles, polygons, and original field problems. [Required of agricultural juniors and mechanical sophomores.]

X. *Analytical Geometry.* Wentworth's Analytical Geometry. The analytical geometry of the straight line, circle, and conic sections; including a general discussion of the general equation of the second degree, and an introduction to the geometry of three dimensions. [Required of mechanical juniors, elective for agricultural seniors.]

XI, XII. *Calculus.* Osborne's Calculus. Differentiation of functions, successive differentiation, indeterminate forms, development of functions in series, maxima and minima, functions of two or more variable, tangents, normals, asymptotes, direction of curvature, singular points, curve tracing, evolutes, envelopes, and order of contact. Integration, application to geometry and mechanics, successive integration, integration of rational fractions, integration by rationalization, by parts, and by series, lengths and areas of plane curves, areas of surfaces of revolution, and volumes of solids. [Required of mechanical juniors, elective for agricultural seniors.]

PHYSICS.

The aims of this department are to cultivate in the student habits of thoughtful observation, intelligent and rapid manipulation, and to give him a general knowledge of natural phenomena. In all courses the subjects are studied from the experimental side, the student spending at least one-half of the time allotted to the work in the laboratory, under the direct supervision of the professor in charge.

The following subjects are offered:

I, II, III. *Elementary.* Carhart and Chute's Elements of Physics; Allen's Laboratory Physics. The properties of matter; mechanics of solids and liquids. Heat, sound, and light. Magnetism and electricity. [Required of freshmen.]

IV, V, VI. *General.* Barker's Physics. Outlined experiments with reference to laboratory manuals. Physical quantities, kinematics, dynamics, work and energy, attraction and potential, and properties of matter. Energy of mass vibration, molecular kinetic energy, radiant energy. Energy of aether-stress, energy of aether-vortices, energy of aether-flow, and the electro-magnetic character of radiation. [Required of mechanical juniors and elective for agricultural seniors.]

VII. *Electric Measurements.* Measurement of resistances, calibration of amperemeters and voltmeters, calculation of the electromotive force of batteries and dynamos, magnetic determinations, heating effect of currents, etc. [Elective for agricultural seniors.]

MECHANICS.

The aim of the instruction in this department is to give the student a thorough insight into the general principles governing prime movers and mechanical movements, and acquaintance with the methods in which these principles may be applied and combined in order to produce the desired effect in all branches of engineering. Instruction is also given in subjects which are rather more technical than theoretical, and the application of theory to practice is never lost sight of. The work is fully illustrated by frequent reference to the engineering and mechanical equipment of the university and other available sources.

The following subjects are required of mechanical students:

I, II. *Founding.* Lectures on core making, loam, dry and green sand moulding; cast iron; flasks, facing, finishing, etc.; also on preparing, charging, tapping out, and stopping up the cupola. [Required of mechanical freshmen.]

III. *Iron Working Machines.* Joshua Rose's Complete Practical Machinist. Study of the use and care of iron machinery, particularly the lathe; speed of different parts; screw cutting, turning excentrics, taps and dies; fitting connecting rods; pumps, etc. [Required of mechanical juniors; fall term; five times a week.]

IV. *Elements of Mechanism.* Stahl and Woods' Elementary Mechanism. Study of the elementary principles underlying mechanical movements and the modes of communicating motion. [Required of mechanical juniors; winter term; five times a week.]

V. *Steam Boilers.* A Treatise on Steam Boilers, by Wilson and Flather. A general study of the different forms of modern steam boilers, their construction, advantages, and disadvantages. [Required of mechanical seniors; fall term; five times a week.]

VI. *Steam Engines.* The Steam Engine, by Homes. The mechanism and principles brought into use in the design of the modern steam engine. Giddings' adjustable model for universal valve movements is used in the class room. Careful study is also made of working engines. [Required of mechanical seniors; fall term; five times a week.]

VII. *Steam Engine Indicators.* The Slide Valve, by Rose, and Hemenway's Steam Engine Indicators. [Required of mechanical seniors; winter term; five times a week.]

VIII. *Engineering Materials.* Merriman's Mechanics of Materials. Theory of resistance of different materials, and study of those principally used in engineering, especially brick, stone, timber, iron, and steel. [Required of mechanical seniors; winter term; five times a week.]

IX. *Hydraulics.* A Treatise on Hydraulics, by Merriman. The flow of water through tubes, in pipes, canals, rivers, and over wiers; measurement of water power and pressure of flowing water. [Required of mechanical seniors; spring term; five times a week.]

X. *Thermodynamics of Gases.* A study of the properties of gases, saturated vapor, and superheated steam, and their application to the steam engine. [Required of mechanical seniors; spring term; five times a week.]

DRAWING.

The aim of the department of drawing is to develop and quicken the ability of observation and to follow as closely as possible the line of work done in the practical drafting rooms of machine shops.

The following subjects are required:

I. *Freehand Drawing.* Drawing from models and copies, with which the department is well supplied. [Required of agricultural freshmen, and of mechanical preparatory students.]

II. *Freehand Sketching.* Sketching parts of machines to be used in instrumental drawing. [Required of agricultural freshmen, and of mechanical preparatory students.]

III. *Use of Instruments.* A short course in straight and curved lines and lettering. [Required of agricultural freshmen and of mechanical preparatory students.]

IV. *Geometrical Constructions.* Geometrical problems used in instrumental drawing. [Required of mechanical freshmen.]

V. *Descriptive Geometry.* An elementary course in projection. [Required of mechanical freshmen.]

VI. *Projection of Shadows.* Isometrical and working drawings. [Required of mechanical freshmen.]

VII, VIII. *Instrumental Drawing.* Detailed copies of parts of machines. Drawing to scale of parts of machines from sketches taken in the shops by the students. [Required of mechanical sophomores.]

IX, X. *Shades and Engineering Colors.* Drawing and tinting machines and parts of machines. [Required of mechanical sophomores and juniors.]

XI. *Parts of Machines.* Designing gears, cams and parts of machines which apply to the study of Mechanics II.. [Required of mechanical juniors.]

XII. *Blue Prints.* Tracing and making drawings to be used in the shops. [Required of mechanical juniors.]

XIII. *Machine Designing.* Designing a boiler or some simple machine; the design to be as original as possible. [Required of mechanical seniors.]

XIV. *Steam Engine Drawing.* This subject is to accompany the work in Mechanics V and VI. [Required of mechanical seniors.]

INDUSTRIALS.

This department is intended to simplify mechanical engineering by teaching practical work in connection with the theory. It aims also to present the practical side of production by running the machine shops as nearly as possible on the principle of actual manufacturing establishments.

I, II. *Wood Working.* Lectures on the care and management of carpenter's tools; exercises in lining, planing, sawing, notching, splicing, mortising, and tenoning. Bench work in wood; exercises in dovetailing, framing, paneling, and special work for the department. [Required of agricultural and mechanical preparatory students.]

III. *Wood Turning.* Exercises in straight and curved turning, compound curves, etc. [Required of agricultural and mechanical prėparatory students.]

IV. *Pattern Making.* A large variety of patterns, including parts of machines,are made for use in the foundry. [Required of mechanical freshmen.]

V, VI. *Foundry Practice.* Exercises in moulding, pouring, charging, and managing the cupola. The castings obtained are used by the students in the machine room. [Required of mechanical freshmen.]

VII. *Iron Work.* Exercises in filing and chipping, and the use of the drill press. [Required of mechanical sophomores.]

VIII. *Iron Planing.* Exercises and special work. [Required of mechanical sophomores.]

IX. *The Engine Lathe.* An elementary course; tapering, screw cutting, etc. [Required of mechanical sophomores.]

X. *The Engine Lathe, Advanced.* Special work; turning up parts of machines, and work for the department. [Required of mechanical juniors.]

XI. *Milling.* Exercises in milling, sawing, gear cutting, spiral cutting, and work on parts of machines. [Required of mechanical juniors.]

XII. *Engineering Laboratory.* Testing the efficiency of boilers, and inspection visits. [Required of mechanical juniors.]

XIII. *Engineering Laboratory.* Testing steam engines, learning the principles and operation of the steam engine indicator and rigging; inspection visits. [Required of mechanical seniors.]

XIV. *Shop Engineering.* General work in shop management, lining shaftings, and setting machines; inspection visits. [Required of mechanical seniors.]

XV. *Experimental Laboratory.* A thesis is produced in connection with experimental work. [Required of mechanical seniors.]

Special subjects of experiment are arranged for those who have taken the baccalaureate of science in mechanics and wish to take graduate work.

THE MECHANICAL SHOPS.

This year the shops have been kept running the entire time. A foundry was placed in the east wing of the building which makes a valuable addition to the shops as it permits the work of the entire engineering school to be carried on systematically. The Whiting cupola purchased has a capacity of melting from 1,000 to 2,000 pounds of iron per hour. All necessary tools, such as flasks, ladles, riddles, etc., to operate the foundry were also purchased. Many useful castings were made by the students during the year. A power hack saw was placed in the machine room which is a great time saver in preparing work for the iron machines.

To provide for the large increase of students three eleven-inch Putnam wood lathes were purchased. These lathes were especially designed for manual training purposes, and permit excellent work to be turned from them. New benches for carpenter work were also added and as soon as possible all the old ones will be entirely replaced, which will give the room a much neater appearance. A tool room system has been put in operation. The room was built on the third floor and a small elevator or dumb waiter is used to carry the tools to and from the room. This plan permits an accurate account to be kept of all small tools. A series of boiler tests were carried on during the year which were very beneficial to the higher classes in Mechanics.

Among the most important apparatus added to the engineering laboratory were Arndt's econometer and a steam engine indicator. The econometer will permit some interesting experiments to be made with steam boilers and will enable us to determine its value as a fuel saver. The value of indicators is well known. They are essential to the study of steam engines and open a wide field for experimenting. The study of engines in the class-room has been much simplified by the purchase of Giddings' Valve Model. This model shows clearly the workings of different kinds of valves, which part of the study the students find very difficult. Excellent progress was made by students in drafting and free-hand drawing. Many working drawings for the shops were made, which was work along practical lines, and therefore valuable to students.

MILITARY SCIENCE AND TACTICS.

The department of Military Science and Tactics is established in accordance with the requirements of an act of Congress donating public lands to colleges, one of the conditions being that military tactics shall be taught. It is under the control of an officer of the regular army, detailed by the War Department for this duty, without any expense to the State, under the provisions of Section 1225, Revised Statutes of the United States. One hundred and fifty Springfield rifles (cadet pattern; similar to those used at

WestPoint) and equipments, and cannon and sabres for artillery and cavalry practice, are loaned to the college by the U. S. Ordnance Department. An allowance of ammunition is annually supplied by the general government for purposes of target practice. All students are required to drill throughout the year. The cadet officers are appointed by the commandant of cadets, subject to the approval of the President. The commissioned officers are usually selected from the senior class, the sergeants from the junior class, and the corporals from the sophomore class, general merit and military efficiency being the qualifications considered.

Besides obtaining the excellent physical results which follow systematic and regular military training, the *morale* of the students will thus be improved. The virtues of patrotism, honor, and truthfulness are cultivated, and habits of neatness, promptness, and obedience are insisted upon

The rules prescribed by the President of the United States for the government of officers of the army detailed as Professors of Military Science and Tactics require the following course of instruction:

1. The course of instruction shall be both practical and theoretical, and shall bé so arranged as to occupy at least one hour per week for theoretical instruction, and at least two hours per week for practical instruction.

2. The practical course in infantry shall embrace small-arm target practice, and, as far as possible, all the movements prescribed by the drill regulations of the United States army applicable to a battalion. Instruction in artillery shall embrace, as far as practicable, such portions of the United States drill regulations as pertain to the formation of detachments, manual of the piece, mechanical maneuvers, aiming drill, saber exercise, and target practice. Instruction should also include the duty of sentinels, and where practicable, castrametation. Such instruction shall

be given by the Professor of Military Science and Tactics personally, or under his immediate supervision.

3. Theoretical instruction shall be by recitations and lectures personally conducted and given by the Professor of Military Science and Tactics, and shall include, as far as practicable, a systematic and progressive course in the following subjects: The drill regulations of the United States army, the preparation of the usual reports and returns pertaining to a company, the organization and administration of the United States army, and the elementary principles governing in the art of war.

The military department shall be subject to inspection under the authority of the President of the United States; such inspection shall be made, when practicable, near the close of the college year. The inspecting officer shall, upon his arrival at the institution, report to the President or other administrative officer in order to obtain from him the necessary facilities for the performance of his duty. A copy of the report of inspection will be furnished the President of the institution by the War Department.

Military drill has become a feature of all the courses in the University and it is required that all students appear at the drill in uniform. Students are advised to come to the college without specially providing themselves with new clothes and to arrange to wear the cadet uniform habitually while at college.

The cost of the uniform is about $18.00. The grade of suiting, including the cap,wears well and proves to be economical.

All male students are expected to provide themselves with uniforms. It consists of a blouse, trousers, and cap, modeled after the West Point uniform, with raised gilt buttons.

COURSE IN MILITARY SCIENCE.

Practical.—Cadets are divided into two classes, First Year and Subsequent Year Cadets.

For all cadets: Practical instruction comprises the schools of the soldier, squad, and company in normal and extended order (Infantry Drill Regulations), guard mounting and guard duty, gallery and range target practice.

For Subsequent Year Cadets: In addition to the above comprises artillery drill, saber exercise, and military signaling with flag and heliograph.

Theoretical.—Cadets are divided into four classes. The winter term is especially devoted to this instruction, which includes the following:

First Year Cadets: Infantry Drill Regulations, including the schools of the soldier, squad, and company, in normal and extended order.

Second Year Cadets: School of the battalion and ceremonies (Infantry Drill Regulations), and U. S. Manual of Guard Duty.

Freshman Class: "Elements of Military Science," Pettit.

Sophomore Class: U. S. Army Regulations, muster rolls and returns, etc., Military Law, and State Laws relating to the National Guard.

The corps of cadets has this year been divided into two companies, with the commandant acting as major. The number of young men in the drill has been seventy-seven.

THE LIBRARY.

The library, which is also the general reading room of the University, is situated on the second floor, in the north wing of the main building. This is a large, well lighted and ventilated apartment. The college students use this room during vacant hours from 8:30 a. m. to 12 m., and from 1 to 3:15 p. m.

The students at all times during the day , for five days in the week, have free access to all the books and periodicals. Three volumes may be taken by any one individual and kept from the shelves for a period of two weeks. Books reserved at the instance of professors as collateral reading for their courses are shelved in their respective rooms, and can be taken out only on application to such professors, who are responsible for them during the period of their reservation.

The library contains 5,750 bound volumes, and in addition several thousand unbound bulletins and reports on agricultural and scientific subjects.

There have been added to the University library, during the fiscal year 1897-8, 1,080 bound volumes and 1,000 pamphlets, including Experiment Station bulletins and publications from the Department of Agriculture at Washington, D. C.

The following agricultural papers and Wyoming newspapers are sent to the University:

- Arkansas—
  - Farmer.
- California—
  - Press and Horticulturist.
  - The Call.
  - West American Science.
- Colorado—
  - Farmer.
  - The Field and Farm.
- Georgia—
  - The Southern Cultivator.
- Illinois—
  - Prairie Farmer.
  - Orange Judd Farmer.
  - Farmers' Review.
  - The Farmer's Magazine.
  - The Elgin Dairy Report.
  - Irrigation Age.
- Indiana—
  - Clover Leaf.
- Iowa—
  - Iowa Homestead.
- Kansas—
  - Farmer.
- Kentucky—
  - The Industrial American.

Louisiana—
  Planter.
Maryland—
  Farmer.
  Southern State.
  Baltimore Weekly Sun.
Massachusetts—
  Farm and Home.
  Ploughman.
  Our Grange Home.
  American Cultivator.
  New England Farmer.
Michigan—
  Grange Visitor.
Missouri—
National Dairyman.
Nebraska—
  Western Resources—
New Hampshire—
  Mirror and Farmer.
New Mexico—
  Southwestern Farm and Orchard.
New York—
  American Agriculturist.
  Rural New Yorker.
  Sugar Trade Journal.
Ohio—
  American Grange Bulletin.
Pennsylvania—
  Germantown Telegraph.
  Public Ledger, daily.
Virginia—
  Southern Planter.
  The Progressive South.
Washington—
  Northwest Mining Review
Wisconsin—
  Hoard's Dairyman.
Ontario—
  Farmers' Advocate.

State Papers—
  Bill Barlow's Budget.
  Boomerang.
  Carbon County Journal.
  Central Wyoming News.
  Cheyenne Tribune.
  Fremont County Gazette.
  Laramie Times.
  Newcastle News-Journal.
  News-Register.
  Otto Courier.
  Rock Springs Independent
  Rock Springs Miner.
  Saratoga Lyre.
  Saratoga Sun.
  Sheridan Journal.
  Sheridan Post.
  Sun-Leader.
  Wheatland World.
  Wyoming Press.

The scientific and general periodicals taken by the library and kept on the tables of the reading room are:

American Machinist.
American Naturalist.
American Gardening.
American Journal of Mathematics.
Agricultural Science.
Annals of American Academy of Political and Social Science.
Bulletins of the Torrey Botanical Club.
Botanical Gazette.
Book News.
Century.
Cosmopolitan.
Colliery Mining Magazine.
Education.
Educational Review.
Electrical World.
Engineer Magazine.
Erythea.
Etude.
Fliegende Blaetter.
Forum.
Garden and Forest.
Harper's Weekly.
Harper's Monthly.
American Journal of Science.
American Geologist.
American Journal of Civics.
Journal Society of Chemical Industry.
Journal of the Chemical Society.
Literary Digest.
Meehan's Magazine.
Microscope.
Mining and Scientific Press.
Monist.
Nation.
Nature.
North American Review.
Outlook.
Physical Review.
Popular Science Monthly.
Psychological Review.
Philosophical Review.
Quarterly Journal of Pure and Applied Mathematics
Review of Reviews.
Science.
Scientific American and Supplement.
Scribner.
Western Electrician.

The University now uses the Dewey Decimal Card Catalogue system, and in addition to the regular cards has those coming from the Department of Agriculture at Washington, containing a complete list of publications sent from that department and its several branches in connection with the Experiment Station work.

Treasurer's Report.

UNIVERSITY OF WYOMING,
Agricultural College,
Laramie, Wyo., June 30, 1898.

Report of Treasurer of said institution, to the Secretary of Agriculture and the Secretary of the Interior, of amount received under Act of Congress of August 30, 1890, in aid of the Colleges of Agriculture and the Mechanic Arts, and of the disbursement thereof, to and including June 30, 1898.

Balance on hand July 1, 1897		$ 7,017 26
Date of receipt of installment for 1897-98, September 4, 1897		23,000 00
Total available for year ending June 30, 1898		$30,017 26
Disbursements thereof for and during the year ending June 30, 1898:		
Agriculture	$1,373 23	
Mechanic Arts	3,479 40	
English Language	1, 967 23	
Mathematical Science	1,787 68	
Natural and Physical Sciences	9,157 21	
Economic Science	3,252 70	
Total expended during the year		21,017 45
Balance remaining unexpended July 1, 1898		$ 8,999 81

I hereby certify that the above account is correct and true, and truly represents the detail of expenditures for the period and by the institution named, and that said expenditures were applied only to instruction in Agriculture, Mechanic Arts, the English language, and the various branches of Mathematical, Physical, Natural and Economic Science, with special reference to their applications in the industries of life, and to the facilities for such instruction.

JOHN C. DAVIS,
Treasurer.

Courses of Study.

AGRICULTURAL COURSE.

For explanation of the Roman numerals, see departmental statements on preceding pages. The Arabic numerals indicate the number of hours a week. Where no numerals appear, 5 is understood. Two hours of laboratory, shop, or field work are counted as equivalent to one hour of recitation or lecture.

PREPARATORY YEAR.

FALL TERM.	WINTER TERM.	SPRING TERM.
History, I.	History, II.	History, III.
English, I.	English, II.	English, III.
Mathematics, I.	Mathematics, II.	Mathematics, III.
Physiography, I.	Physiography, II.	Physiology, I.
Industrials. I.	Industrials, II.	Industrials, III.

FRESHMAN YEAR.

Physics, I.	Physics, II.	Physics, III.
Mathematics, IV.	Mathematics, V.	Mathematics, VI.
Drawing, I, 4.	Drawing, II, 4.	Drawing, III, 4.
German, I.	German, II.	German, III.
Botany, I, 4.	Botany, II, 4.	Botany, III, 4.
English, VII, 1.	English, VIII, 1.	English, IX, 1.

SOPHOMORE YEAR.

Zoology, I.	Zoology, II.	Zoology, III.
German, IV.	German, V.	German, VI.
Chemistry, I.	Chemistry, II.	Chemistry, III.
English, XIII, 3.	English, XIV, 3.	English, XV, 3.
Agriculture, I, 2.	Agriculture, II, 2.	Agriculture, III, 2.

JUNIOR YEAR.

Geology, I.	Geology, II.	Geology, III.
Entomology, I, 3.	Entomology, II, 3.	Horticulture, II, 3.
Philosophy, I.	Horticulture, I.	Mathematics, IX.
Agriculture, IV, 2.	Agriculture, V, 2.	Agriculture, VI, 2.
Chemistry, VII.	Chemistry, XI.	Meteorology, I, 2.
		Irrigation, I, 3.

SENIOR YEAR.

Political Science, IV.	English, XX, 1.	English, XXI, 1.
English, XIX, 1.	Elective, 15 hours.	Elective, 15 hours.
Elective, 10 hours.		

MECHANICAL COURSE.

For explanation of the Roman numerals, see departmental statements on preceding pages. The Arabic numerals indicate number of hours a week. Where no numeral appears, 5 is understood. Two hours of laboratory, shop, or field work are counted as equivalent to one hour of recitation or lecture.

PREPARATORY YEAR.

FALL TERM.	WINTER TERM.	SPRING TERM.
History, I.	History, II.	History, III.
English, I.	English, II.	English, III.
Mathematics, I.	Mathematics, II.	Mathematics, III.
Drawing, I.	Drawing, II.	Drawing, III.
Industrials, I.	Industrials, II.	Industrials, III.

FRESHMAN YEAR.

Physics, I.	Physics, II.	Physics, III.
Mathematics, IV.	Mathematics, V.	Mathematics, VI.
Drawing, IV.	Drawing, V, 3.	Drawing, VI, 3.
French, I, or German, I.	Mechanics, I, 2.	Mechanics, II, 2.
Industrials, IV.	French. II, or German, II	French, III, or German III
	Industrials, V.	Industrials, VI.

SOPHOMORE YEAR.

Drawing, VII.	Drawing, VIII.	Drawing, IX.
French, IV, or German, IV.	French, V, or German, V	French, VI, or German, VI
Chemistry, I.	Chemistry, II.	Chemistry, III.
Mathematics, VII.	Mathematics, VIII.	Mathematics, IX.
Industrials, VII.	Industrials, VIII.	Industrials, XII.
English, VII, 1.	English, VIII, 1.	English, IX, 1.

JUNIOR YEAR.

Mechanics, III.	Mechanics, IV.	Chemistry, XII.
Mathematics, X.	Mathematics, XI.	Mathematics, XII.
Physics, IV.	Physics, V.	Physics, VI.
Drawing, X.	Drawing, XI.	Drawing, XII.
Industrials, X.	Industrial, XI.	Industrials, XII.
English, X, 1.	English, XI, 1.	English, XII, 1.

SENIOR YEAR.

Political Science, IV.		
Mechanics, V.	Mechanics, VII.	Mechanics, IX.
Mechanics, VI.	Mechanics, VIII.	Mechanics, X.
Drawing, XIII.	Drawing, XIV.	Thesis.
English, XIX, 1.	English, XX, 1.	English, XXI, 1.
Industrials, XIII.	Industrials, XIV.	Industrials, XV.

UNIVERSITY OF WYOMING,

LARAMIE, WYOMING.

REPORT OF THE PRESIDENT of said institution to the Secretary of the Interior and the Secretary of Agriculture, as required by act of Congress of August 30, 1890, in aid of Colleges of Agriculture and the Mechanic Arts.

RECEIPTS FOR AND DURING THE YEAR ENDING JUNE 30, 1898.

1. Balance on hand July 1, 1897, over and above all indebtedness (excluding funded debt, if any)	$ 7,680 01
2. State aid; (a) Income from endowment granted by state	
(b) Appropriation for current expenses	8,076 69
(c) Appropriations for building or for other special purposes	
3. Federal aid; (a) Income from land grant, act of July 2, 1862	
(b) Additional endowment act of August 30, 1890	23,000 00
(c) For experiment stations, act of March 2, 1887	15,000 00
4. Fees and all other sources (fees, $609. 96; sales, 556.77)	1,166 73
Total	$54, 923 43

EXPENDITURES FOR AND DURING THE YEAR ENDED JUNE 30, 1898.

(Not necessarily a balance sheet as compared with Division II. above.)

1. Instruction in the subjects specified in sec. 1, act of August 30, 1890[*]	**$21,017 45**
2. Instruction in all other subjects, if any, not mentioned in Question 1 of this series	**3,200 00**
3. Administrative expenses (President's, Secretary's Treasurer's, Librarian's salary, clerical service, fuel, light, etc.)[†]	**2,200 00**
4. Experiment Station	**15,556 77**
Total	**$41,974 22**

PROPERTY, YEAR ENDED JUNE 30, 1898.

Value of all buildings, $102,000; of other equipment, $45,000.

Value of above property (an estimate only is expected) not used for instruction in the subjects specified in section 1 of act of August 30, 1890, Buildings, all used; of other equipment, $15,000.

Total number of acres, 356; acres under cultivation, 180; acres used for experiments, 180; value of farm lands, $9,540; amount of all endowment funds, none.

Number of bound volumes, June 30, 1898, 5,750; pamphlets, 4,000.

FACULTY DURING THE YEAR ENDED JUNE 30, 1898.

	Male.	**Female.**
1. College of Agriculture and Mechanic Arts;		
(a) Preparatory classes	**9**	**2**
(b) Collegiate and special classes	**9**	**2**
(c) Total, counting none twice	**9**	**2**
2. Number in all other departments (excepting duplicates)	**2**	**1**
3. Number of staff of Experiment Station	**6**	**1**

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[*] The answer to this question will include not only the amount received under the act of August 30, 1890 ("Morrill Act"), but also all amounts that are expended for the subjects specified in that act, irrespective of the character of the funds the amounts may be drawn from (State, tuition fees, or endowment, etc.)

[†] It may be convenient for many institutions to answer 2 and 3 as one question. Cost of new buildings is given under Division. I.

STUDENTS DURING THE YEAR ENDED JUNE 30, 1898.

1. Colleges of Agriculture and Mechanic Arts:

	Male.	Female.
(a) Preparatory classes	6	0
(b) Collegiate and special classes	12	1
(c) Post Graduate courses	0	0
Total, counting none twice	18	1

	Male.	Female.
2. Number in all other departments	70	96

3. Number of students that pursued courses in agriculture, 3; mechanical engineering, 16; electrical engineering, 0; mining engineering, 14; architecture, 0; household economy, 0; veterinary science, 0; military tactics, 77. (It is not expected that the sum of these figures will equal the number of students given above.)

4. What degrees and how many of each kind were conferred in 1897-'98?

   On men, 6 (M. A., 1; B. A., 3; B. S., 1; B. Ped., 1.)
   On women, 6 (B. A., 3; B. Ped., 3.)

5. What and how many honorary degrees were conferred in 1897-'98? None.

[Signed] ELMER E. SMILEY,
President. (after July 1, 1898.)
FRANK PIERREPONT GRAVES,
President (until July 1, 1898.)

UNIVERSITY OF WYOMING.

Agricultural College.

EIGHTH ANNUAL REPORT

. . . OF THE . . .

WYOMING EXPERIMENT STATION,

LARAMIE, WYOMING.

For the Fiscal Year 1897-98.

Wyoming Agricultural Experiment Station.

UNIVERSITY OF WYOMING.

BOARD OF TRUSTEES.

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PRESIDENT OF THE UNIVERSITY OF WYOMING.

FRANK PIERREPONT GRAVES, Ph. D., Litt. D., LL. D.

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C. B. RIDGAWAY, A. M	Physicist and Meteorologist
G. R. HEBARD, A. M., Ph. D	Secretary

SUPERINTENDENTS.

J. F. LEWIS	Sheridan Experiment Farm
J. S. MEYER	Lander Experiment Farm
W. H. FAIRFIELD, B. S	Wyoming University Experiment Farm

EIGHTH ANNUAL REPORT

. . . OF THE . . .

WYOMING AGRICULTURAL EXPERIMENT STATION

I hereby submit the eighth annual report for the Wyoming Agricultural Experiment Station in compliance with congressional enactment. The report covers the work of the Station during the fiscal year ending June 30, 1898.

ORIGIN AND PURPOSE.

The Wyoming Agricultural Experiment Station is the department of research of the College of Agriculture of the University of Wyoming. Congress in 1887 appropriated $15,000 annually for this purpose, and on January 10, 1891, the Wyoming Legislature authorized the University of Wyoming to receive this appropriation. The work of the Station is to aid in the acquiring and diffusing among the people of the United States, and especially of Wyoming, useful and practical information on subjects connected with agriculture, to conduct scientific investigations and experiments on the physiology of plants and animals; to investigate animal and vegetable diseases and parasites; to chemically analyze soils and water and vegetable and animal products; to acclimate grains and grasses, fruits and vegetables, to our arid climate and high altitude; to ascertain the best methods of irrigation, and of retaining the moisture in the soil; to find the best breeds of stock, and the best varieties of field and garden crops for the various portions of Wyoming; and to carry on any other experiments which promise to benefit our agricultural and grazing interests. The results of these experiments are published in the Station Bulletins, which are sent free upon request to residents of this State.

The published results of the Station for 1897-98 ar comprehended in four bulletins, which are appended in full to this report. All these bulletins, particularly that on fruit growing, have aroused much interest and have had a wide circulation both in and out of Wyoming. The title and brief summary of each bulletin is given below.

NO. 34. FRUIT GROWING IN WYOMING.

This is an extensive report, giving the results of the experiments with fruit carried on at the Home Station and the five sub-stations during the last five years, together with the statements of the results of nearly all the fruitgrowers in the state. In the conclusion a list of varieties is given, which are apparently best adapted to the conditions in Wyoming.

NO. 35. MECHANICAL ANALYSIS AND WATER CONTENT OF WYOMING SOILS.

This is a bulletin of thirty pages, giving the results of a mechanical analysis of some typical soils of the State and a comparison of them with typical soils from the humid regions. It also gives the moisture content of the soil of the Laramie Experiment Farm during the growing season. It contains a comparison of the greatest yields of the common farm crops at the various farms where the soil was obtained.

NO. 36. SUGAR BEETS IN WYOMING.

This bulletin treats the sugar beet problem of Wyoming in a concise manner. It reports the results of the experiments at the Home Station and the sub-stations, and the results of the co-operative tests among farmers since the establishment of the Station. It deals with the importance of the sugar beet industry, the process of manufacture, the prices paid for beets, the requirements of a sugar factory, the location in Wyoming, the literature of the subject, and the method of cultivation.

NO. 37. THE STOOLING OF GRAINS.

This bulletin reports a co-operative experiment, carried on with grain planted at different distances apart and at different rates of seed to an acre. The effects of different amounts of seed at various altitudes are compared. The relative production of wheat, oats, and barley is treated.

IRRIGATION PROBLEMS.

The idea has been growing for some time upon the Station that its experiments were spread over too wide a field and that co-operation was not sufficiently practised among its members. A proposal to concentrate the work of the Station on problems involved in irrigation was made April 7th by the Chemist, Prof. E. E. Slosson, and supported by the folowing outline of work already done and of suggestions for the future.

OUTLINE.

The Experiment Stations are organized to study one single subject and that is the growth of useful plants. Because conditions controlling plant life are so different in different parts of the country it is necessary that stations should be established in as many localities as possible so that agriculture under various circumstances could be experimented upon. The problems to be solved by each station are therefore primarily those peculiar to its station. The district surrounding the Wyoming station is arid, that is, there is not a sufficient amount of water in the soil to supply growing plants. The study of the cause and cure of aridity is, then, the problem set by nature to be solved by the Wyoming Experiment Station and is stated as such in the first bulletin on the Organization and Proposed Work of the Station. The aridity of Wyoming is due to two causes; first, the high altitude which causes excessive evaporation, second insufficient precipitation. It can, therefore, be remedied in two ways, by adding more water to the soil or by keeping what water there is. Evaporation occurs from two surfaces, from the soil and from the plants. Methods of cultivation which check evaporation from the soil have been devised and tried in a practical way by the Agriculturist. Some original experiments made by the Botanist on the influence of altitude on the loss of water by transpiration resulted in the discovery that the winter-killing of trees was largely due to this excessive evaporation, and this fact has since been generally accepted and published by physiological botanists. (Bulletin No. 15).

Aridity might be remedied according to the second method, that of adding water, in two conceivable ways: increasing the rainfall and irrigation. No experiments on increasing the rainfall have been carried out by the station. Frank Melborne and the generous citizens of Cheyenne have attended to that matter for themselves and the station believes that it is best to leave this line of experimentation to private initiative. Before artificial addition of water can be properly discussed, it is necessary to know just how much water is supplied to us by nature and how much is lost by evaporation. Consequently continuous observations on precipitation and evaporation have been made at Laramie and elsewhere, and five bulletins (No. 4, No. 10, No. 16, No. 17, No. 24.) on the subject have been published by the meteorologists of the station. For irrigation there are three sources of water available, artesian wells, reservoirs, and streams. A bulletin on Artesian Wells in Southern Wyoming was published in 1894 and a bulletin locating all the important artesian basins of the State is now in preparation by the Geologist. The selections of suitable sites for storage reservoirs is being made by the government. The guaging of streams and allotment of water is done by the State. The station can therefore devote its entire attention principally to the agricultural part of the question.

Where watering is done by rain, pure water is added to the soil and drained off underneath carrying with it the soluble salts of the soil In watering by irrigation water containing salts is added to the soil and pure water evaporated from the surface. In this way soluble salts, commonly known as alkali, are constantly being added to the soil and accumulated at the surface. This in time ruins the land, so the alkali question becomes an important part of the irrigation problem.

When the station was established, obviously the first thing was to find out how much alkali there was in the soil and how much was being added to it by irrigation. This was determined by analysis of the soil of the farms by the

Chemist (Bulletin No. 6). Analysis of as many different samples of alkali as could be procured have been made by the Chemist but are not yet published. To determine how much alkali was being added by irrigation required the knowledge of the amount and composition of the water used in irrigation and the amount and composition ofdrainage water. The first two points were determined by the horticulturist by measuring the water at entering and waste weirs and by the chemist who analyzed the water at thess two points. (Bulletins No. 8 and 24). The drainage question has not been attacked. Neither has the evaporation from the surface of soil containing alkali been determined.

Since the injury to plant life is not proportional to the total amount of alkali in the soil but rather to the concentration of the solution of alkali it becomes necessary to determine the amount of water present in the soil. This has been done by the physicist. (Bulletin No. 31). The same bulletin gives also the size of the soil particles, a necessary preliminary to working out their number and the water and air space between them. Two bulletins have been published on the source of alkali in the experiment farms by the geologists of the station. (Bulletins No. 6 and 14). One bulletin has been issued by the director (No. 18) on the Reclamation of Arid Lands. The flora of the State has been studied with special reference to the plants growing in desert regions. (First Report of Flora of Wyoming, Bulletin No. 28 and Bulletin No. 15 by horticulturist). A large amount of practical work has been done on vraious methods of irrigation and prevention of the rise of alkali on the six farms of the state. (Bulletins No. 11, 17, 22, and 25).

It seems now that we have pretty thoroughly cleared up the preliminary and routine work, and now have the choice before us of whether we shall turn attention to other lines of work or whether we shall attack the numerous unsolved problems connected with irrigation and the effect of alkali. It seems to me that since the State makes comparatively few calls on us for practical information we can afford to devote a large part of our time to purely scientific research. I, therefore, move the previous question first put before us in 1891, and propose that we unitedly and persistently attack this group of problems.

In making suggestions to other departments as to new lines of work I am aware I am running a risk of being regarded as impertinent and presuming, and shall ask you to mimimise the odium of this position by considering them as suggestions only and by making others in return. Of course most of these plans are not original with me and on some of them we have already done considerable work. The origin of alkali is entirely unknown; none of the theories seem to be satisfactory. Since we have here beds of quite pure salts of sodium and magnesium acres in extent and several feet in depth we have the best possible opportunity to throw new light on this subject. The geologist is already working on this. The practical difficulties in the manipulation of the soil under irrigation are well known. Very little is known, however, as to the cause of the peculiarities of irrigated soil, and it is very likely that effective remedies for the rise of alkali, puddling, etc., will not be found until pure scientific research has shown what are the movements of air and water in the soil and how the presence of soluble salts effects the soil texture. This of course leads into the mysterious realm of "molecular physics," where so much brilliant work is now being done but where so much remains undone. The movement of water in soil under irrigation is a physical one but the chemist has for two years made determinations of the amount and character of the alkali at different depths. The work will be continued another season before publication.

—(d)

The fundamental problem of irrigation is undoubtedly the effect of deficient moisture and excess of soluble salts on plants, where least has been done because of the immense difficulties in the way.

If this station could contribute to the solution of any of these problems, it would be of more value to the practical agriculture of this region than years of routine work.

E. E. SLOSSON.

PLANS OF STATION WORK FOR 1898.

The following plans for the season of 1898 have been well started. It will be seen that most of them look to carrying out the new policy of the station. They were recommended by the Station Council and approved by the Agricultural Committee of the Board of Trustees.

THE AGRICULTURIST AND HORTICULTURIST.

1. Soil Investigations.
    (1) Permanent Soil Work.
    (2) Continuing Sub-Soil Experiment (third season).
2. Small Grains (Study of varieties).
3. Forage Crops (Cultivated and Native. Co-operation with the Department of Agriculture).
4. Alkali Investigation.
5. Irrigation Investigations (Co-operative with State Engineer and the Department of Agriculture).
6. Additional fruit tests on a small scale.
7 Fertilizer Experiment—Potatoes with Potash.
8. Sugar Beets (Co-operative tests).
9. Asparagus on heavy and light alkali soil.
10. Celery—varied treatment.
11. Forestry—Study of cultivated, shade, and forest trees and Co-operation with the Division of Forestry.
12. Floriculture for Decoration.

THE BOTANIST.

1. The continuation of the field work and accumulation of data upon the subjects heretofore undertaken but as yet not completed. (As given for 1897).
2. A co-operative study of alkali in its relation to plant life.
    (1) The comparative structure of alkali resistent and non-resistent vegetation.
        (a) External characteristics.
        (b) Histology of.
3. Experiments with promising forage plants.
    (1) For normal soils.
    (2) For alkali soils.

THE CHEMIST.

1. Effect of alkali on germination of seeds.
2. Analysis of soils and alkali.
3. Analysis of alkali-resisting plants.
4. Analysis of sugar beets.
5. Extraction of soluble salts from rocks.

THE GEOLOGIST.

1. Completion of the preliminary bulletin on the artesian basins of the state.
2. The origin of alkali.
    (1) The geological location of these salts and their relation to the various terranes.
    (2) The way alkali finds its way into the soils.
    (3) Preventing further accumulation if possible.
3. Wind erosion and its relation to soil formation in the arid districts.
4. To complete the preliminary work on the birds of Wyoming and arrange notes for publication.

THE PHYSICIST.

1. Capillary movements of water in soils.
2. Relation of air to soils.
3. Puddling of soils.

THE METEOROLOGIST.

1. Continuation of the work of making observations and co-operating with the State and United States Weather Service.
2. Observations on the precipitation from as many places in the State as possible.
3. Observations upon the direction and force of the air currents at Laramie.
4. Study of terrestrial radiation and sunshine.

Report of Station Council.

REPORT OF THE DIRECTOR.

By advice of the Office of the Experiment Stations no appropriations have been made for the sub-farms this year, except a small amount granted during the first six months to Lander and Sheridan. The sub-farms have not been regularly abandoned and it is hoped that the next legislature will find some means of conducting them with state funds. If this cannot be done, the farms that do not from their deeds revert to the donors will be used for co-operative experiments with the station.

The Wheatland and Saratoga farms will probably revert without further action. The Saratoga farm has never been of great service and the Wheatland farm has completed its usefulness by demonstrating that nearly everything grows well in that portion of the state.

The sub-farms at Lander and Sheridan have been splendidly conducted under superintendents J. S. Meyer and J. F. Lewis respectively. The thanks of the station are due them for long and faithful service . The Lander farm has been rented to Mr. Meyer for a small consideration, with the added agreement that he care for the property, maintain the fruit orchard, carry out a co-operative experiment with sugar beets, and make regular reports to the Station

The Sheridan farm, with the exception of the horses and wagon, which were sold, was leased to Mr. George C. Shetler in consideration of his taking care of the property, making regular reports on the fruit trees, the weather observations, and other matters, and of his co-operating in the sugar beet experiment. The general appearance of the farm under his administration thus far is excellent and the

Director has every reason to believe Mr. Shetler a thoroughly reliable man.

Nothing has beeen done with the farm at Sundance, as it was impossible to rent it satisfactorily. Hon. A. E. Hoyt, the former superintendent, has agreed to care for the property until definite arrangements with regard to it are made. Some of the implements and machines have been sold.

The suspension of appropriations for the sub-farms and the sale of a portion of the equipment has made possible some improvements upon the Station. The Laramie farm has been greatly improved in appearance and efficiency. A dwelling house with two stories has been nearly completed and will enable a superintendent to live there comfortably. A shed for the accommodation of teams has been built, which can be made a part of a larger structure. It is hoped that it will be possible to erect an adequate barn within a year or two, but until that time it has seemed best to use the shed rather than to construct a small barn that would be an eye-sore and have to be torn down before building again.

An artesian well has been sunk, in the hope of obtaining a permanent water supply, but the water which has appeared is alkaline. It is believed that by lowering the pump and shutting off the upper streams of water, and adding a windmill and tank, good water will be obtained.

To the general equipment has been added a Deering pony binder, a disc harrow, and a Fairbanks wagon scales.

On the college campus, as noticed elsewhere, a large wing has been built on the greenhouse and fitted with steam pipes. Nearly 20,000 plants have been grown here during the winter.

The Director has inspected the subfarms, and the Vice Director in company with Dr. E. W. Allen, visited the sub-station at Lander. In July the Director and Vice Director were sent to Minneapolis to the convention of the Association of American Agricultural Colleges and Experiment Stations. This opportunity to come into the atmosphere of the best thought on the subject of agricultural science was refreshing and inspiring and will be of the greatest benefit to both delegates.

REPORT OF THE AGRICULTURIST AND HORTICULTURIST.

The bulletins issued from this department during the last fiscal year were No. 34, "Fruit Growing in Wyoming" and No. 37, "The Stooling of Grains." My assistant, Mr. Fairfield has carried out another valuable alkali experiment, in which some new discoveries have been made. The data obtained in this experiment will be ready for publication by the first of July.

Last season's experimental work was carried out as planned, something being done along each line of investigation with the exception of measurements of irrigation water at Sheridan. On account of the lack of funds for that substation and the large amount of other work a water register was not sent to Sheridan for this purpose.

The experiment in the stooling of grains at different altitudes was finished and reported. The investigations being carried on this season according to the plans are well under way.

The department library has received, in addition to the current works on agriculture, horticulture, and entomology, two important additions. Through the Office of Experiment Stations, Sir Henry Gilbert presented the station with a full set of the "Rothamsted Memoirs" and we have obtained a set of the proceedings of the American Pomological Society, back to 1871.

A book case and cabinet in which to store photographs and other material was placed in the office. To the photographic equipment we have added a Zeiss wide-angle lens, and, by several departments clubbing together, an enlarging, reducing and copying camera.

In addition to the regular investigations of the station we are now co-operating with the Divisions of the Department of Agriculture and State Engineer as follows:

In grasses and forage plants with the Division of Agrostology.

In sugar beets, seeds and plants, with the Office of Experiment Stations.

In growing forest trees with the Division of Forestry.

In notes upon injurious insects with the Division of Entomology.

In irrigation with the State Engineer and the Department of Agriculture.

So far as we could without interfering with our own planting we have aided the farmers located near the station by loaning to them various tools without charge, and small amounts of seed have been given out to those who made requests early.

Irrigation records have been kept upon the Experiment Farm as heretofore, and this year we are making measurements of the water used upon the farm of J. W. Sigman, sixteeen miles west of Laramie under the Pioneer Canal.

We have been greatly aided in the work of the department during the college year by students. The stenographer and typewriter in the office and assistants in the greenhouse have been of especial value. Mr. Fairfield has assisted faithfully with the work. Practically all the detail of the farm and greenhouse work has been looked after by him, and in addition he has carried out the alkali experiment before referred to, as well as assisting with much of the routine in the office.

REPORT OF THE BOTANIST.

The work of the year has been largely a continuance of the work of the previous year. The accumulation of data has gone forward more or less uninterruptedly and some of the questions under consideration, it is hoped, may soon be disposed of by publication or otherwise. Among those that are being considered are the following: The native parasitic fungi; the edible fungi; the native ornamental trees and shrubs; forests and forestry.

A work that always requires more or less of the station botanist's time is attention to the weed question and the diseases of plants. Of weeds we have an increasing army which indicates that here, as in other newly settled communities, the first comparative freedom from troublesome foes begets an indifference that cannot be overcome until the fields are foul with foreign introductions. From plant diseases we are remarkably immune. As stated in former reports, this may be in part attributed to the dryness of our climate. With the exception of the wheat and oat smuts no serious loss has been reported from any fungus disease whatever.

One of the most important undertakings of the year was the study of "The flora of the Red Desert and its relation to the stock interests of the State." This was begun under the direction of this station but was carried to completion under the direction of the Division of Agrostology U. S. Department of Agriculture. It involved the use of a large part of the last summer vacation in the field, and later much time in the study of the material secured. Upon this work there has been prepared an exhaustive report which has been accepted for publication as a bulletin from the Division of the Department of Agriculture before mentioned. This report is now in the hands of the printer and will undoubtedly soon appear, after which this station has the privilege of republishing such portions of it as may be deemed advisable.

Among the more or less co-operative enterprises, to which this department has contributed its mite, may be mentioned the following: The collection of certain weed seeds in quantity for the Division of Botany, U. S. Department of Agriculture, these to be used in the preparation of sample sets of the important weeds of the United States; a brief report upon the genus callamagrostis and the contribution of some specimens of poisonous plants, to the same Division, for exhibition at the Trans-Mississippi Exposition; the contribution of some notes upon the "sage brushes" of the arid districts and other matters of like character, inquiriesconcerning which are frequently received.

The correspondence of the department, of course, is on the increase, owing to the larger number of inquiries concerning Experiment Station matters both from within and from without the state.

The herbarium of the station has been greatly strengthened during the year and is now especially rich in specimens of grasses and other forage plants. Among the additions during the year must be noted some new species of grasses and salt-sages that give promise of some economic importance. Some of these are being grown to test their value as forage plants on strongly saline soils.

REPORT OF THE CHEMIST.

The time of this department has been almost entirely devoted to the alkali problem which is being studied in two ways: by the analysis of alkali from all parts of the state and by experiments on the effect of alkali on the germination of seeds. Over ninety samples of alkali soils have been collected and most of them analyzed. Some interesting results have been obtained on the amount of water absorbed by seeds of different kinds from solutions of various salts at different concentrations but the work will be continued for some months yet before publication. The composition of the alkali-resisting plants of the state will be studied in comparison with plants of the same genus which will not grow in alkali soil.

In April, Bulletin No. 36 on Wyoming Sugar Beets was published, giving the results of sugar beet culture in the State for seven years and information as to the establishing of factories.

REPORT OF THE GEOLOGIST.

During the year there was collected considerable data pertaining to the various lines of investigation. The following work is under way:

The Artesian Basins in Wyoming.

Wind Erosion and its Relation to Soil Making in the Arid Region.

The Origin of Alkali.

The Birds of Wyoming.

EXPERIMENT MATTERS.

Last summer I completed my survey for the bulletin on the Artesian Basin in Wyoming. The work completed was geological sections of the BigHorn Mountains, of the Big Horn Basin and the eastern slope of the Shoshone Mountains and a section of Ferris Mountains. It has been utterly impossible, owing to the rush of work to make the geological maps and section and to work up my notes for the bulletin. It will be quite an extensive discussion of the subject and will take not less than forty days to complete it for the press. I have also taken valuable notes in wind erosion at all points visited in the state.

Since the station has concluded to take up the subject of alkali and to work out all the problems in connection with it in Wyoming, I have been assigned the subject of the

Origin of Alkali. I realize that it is a great problem to undertake to solve, but there is not a better field to work in than Wyoming to accomplish this end. During the coming season I expect to add some valuable data pertaining to this subject.

THE BIRD WORK.

Last summer I employed Mr. Gilmore to collect bird skins and by his efforts coupled with my own while in the field the collection at present numbers about 400 specimens. A great many of these are new to the State and have not been taken in the Rocky Mountains before. By corresponding with other men who studied the birds of Wyoming to some extent, I have a complete record for Wyoming of 277 species and varieties. With another season's work the list should reach at least 300 species. Besides the collection, valuable notes on the birds have been kept and quite a collection of birds' eggs and nests taken.

REPORT OF THE PHYSICIST,

During the past year the physical analysis of some of the typical soils of Wyoming was completed and the results, together with the determination of the quantity of moisture in the soil in the field during the growing season, published in bulletin No. 35. The method formerly used for determining the moisture content of soils has proved very unsatisfactory, hence we hope another year to procure and install an instrument for the electrical determination of the amount of salts and moisture in the soil.

The following are some of the physical properties of the soil which are being examined as rapidly as circumstances will permit

Capillary movements of water in soils.
Relation of air to soils.
Puddling of soils.

REPORT OF THE METEOROLOGIST.

The work of the meteorological department during the past year has been similar to that of previous years. Observations have been taken of the relative humidity, maximum and minimum temperatures, pressure of the air, rainfall, snowfall, velocity and direction of the wind, evaporation, percentage of sunshine, and temperature of the soil at various depths. A self-registering apparatus, operated by an electric battery, is used in recording the velocity and direction of the wind. All observations, excepting amount of rainfall and snowfall, are taken each day at 7 a. m. and 7 p. m.

It is hoped that next year an eletrometer and a seismograph may be added to our list of instruments, and that some experiments may be made with scientific kites.

TREASURER'S REPORT.

WYOMING AGRICULTURAL EXPERIMENT STATION,
Laramie, Wyoming,
In Account With
THE UNITED STATES APPROPRIATION, 1897-8.

DR.

To Receipts from the Treasurer of the United States, as per appropriation for the fiscal year ending June 30, 1898, as per Act of Congress approved March 2, 1887		$15,000 00

CR.

By Salaries	$3,778 33	
Labor	4,732 71	
Publications	1,147 87	
Postage and Stationery	568 02	
Freight and Express	189 06	
Heat, Light and Water	1,064 41	
Chemical Supplies	387 72	
Seeds, Plants and Sundry Supplies	337 33	
Feeding Stuffs	150 65	
Library	114 75	
Tools, Implements and Machinery	612 30	
Furniture and Fixtures	365 83	
Scientific Apparatus	247 85	
Traveling Expenses	531 92	
Contingent Expenses	21 25	
Building and Repair	750 00	
		$15,000 00

We, the undersigned, duly appointed auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Wyoming Agricultural Experiment Station for the fiscal year ending June 30, 1898; that we have found the same well kept and classified as above, and the receipts for the year from the Treasury of the United States are shown to have been $15,000.00, and the corresponding disbursements $15,000.00, for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving no balance on hand.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2, 1887.

[Signed] T. F. BURKE,
[Seal] J. O. CHURCHILL,
H. L. STEVENS,
Auditors.

Attest:
GRACE RAYMOND HEBARD,
Custodian.

SUPPLEMENTARY STATEMENT.

DR.		
To Receipts from sale of Farm Products and Fees	**$556 77**	**$556 77**
CR.		
By Heat, Light and Water	**218 40**	
Building and Repair	**338 37**	**$556 77**

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UNIVERSITY OF WYOMING.

Agricultural College Department.

WYOMING EXPERIMENT STATION,

LARAMIE, WYOMING,

BULLETIN NO. 34.

NOVEMBER, 1897.

Fruit Growing in Wyoming.

BY THE HORTICULTURIST.

Bulletins will be sent free upon request. Address: Director Experiment Station, Laramie, Wyo.

Wyoming Agricultural Experiment Station.

UNIVERSITY OF WYOMING.

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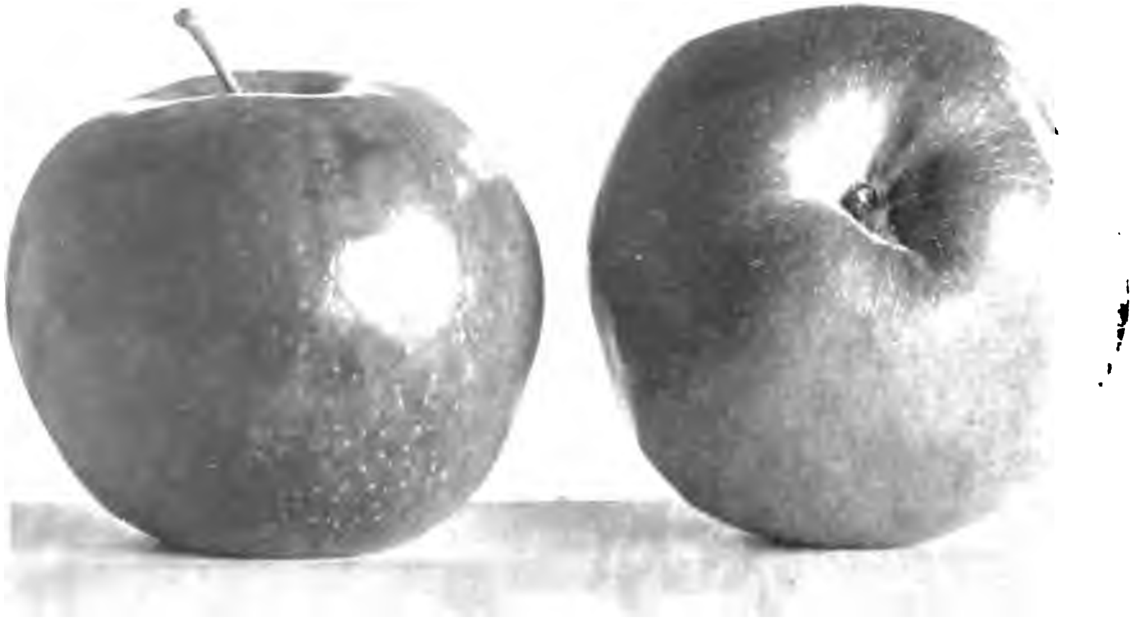


WEALTHY APPLES, Natural Size. Raised by J. Lund, Laramie, 1897.

Fruit Growing in Wyoming.

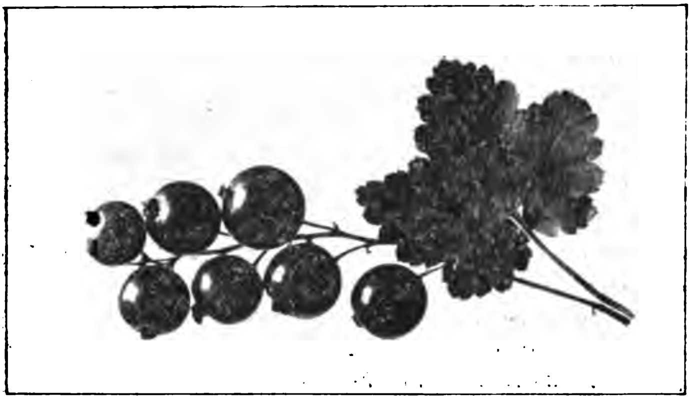
B. C. BUFFUM.

This bulletin is issued to report the results of the experiments with fruits which have been in progress upon the experiment farms since the first plantings in the spring of 1892. The experiments planned were practically the same for each of the experiment farms, although the plantings were somewhat less extensive upon the farms where the conditions were known to be less favorable. The fruit investigations have been given varying amounts of attention upon each farm. This has been due to several causes, among which may be mentioned the more or less favorable conditions, the newness and importance of other agricultural investigations, local accidents to small fruits or orchards, and the personal taste of each superintendent. Where accidents occurred to destroy a strawberry bed or part of an orchard, and lack of funds prevented replacing them at once, the experiments were delayed. It is largely due to this fact that it is impossible to report experiments with different classes of small fruits upon some of the farms. The length of time has not been sufficient since planting orchards to draw definite conclusions. Some of the trees are beginning to bear fruit and indicate in a general way what may be expected of tree fruits. Farmers can safely plant those varieties which have fruited in their section of the state. No doubt other varieties will succeed, but until they have been tested, planting will be a matter of experiment.

Horticultural operations in Wyoming are still new. Therefore up to the present time we have merely attempted to demonstrate whether or not certain fruits could be raised in the different sections of the state. We believed that they could be, but it had not been demonstrated. Before the Experiment Station was established, perhaps half a dozen farmers in different sections had some fruit planted. In 1892 the most liberal estimates from different counties placed the total amount of land in the state planted to fruit at less than 85 acres, and there was probably not more than half that amount. It is very doubtful if the total amount now will exceed one hundred acres of land actually planted to fruits of any kind in the whole state, and certainly the estimate is large enough if we confine it to orchard or other fruits which are in bearing. There has been, however, a change of heart in regard to all branches of agriculture in the last few years. The state is rapidly settling up and many are evincing great interest in the possibility of fruit raising.

As a matter of history, as well as to demonstrate what can be done along this line, we have, in addition to our own experiments, attempted to represent all the fruit growers in the state. We have been unable to visit or get reports from Uinta county, and it is probable there are some fruit growers there that we have been unable to represent. So far as we could get statements from growers of the state, or from their neighbors, they are given in the bulletin. The cultural directions given and notes on irrigation are only such as apply to our own conditions. No attempt has been made to write exhaustively upon the subject, but it is hoped that such information as is given will be of benefit to those who may wish to grow fruits and to new comers to the state who are unacquainted with our conditions. It is hoped also that the bulletin will demonstrate to those who are looking for homes in the West the fact that Wyoming has agricultural and horticultural possibilities of her own. The traveler who crosses our state on any of the railroad lines sees little agricultural development and is apt to conclude that our plains and mountains are only pastures for cattle, horses, and sheep. If this bulletin stimulates a part of our people who have homes, to better their conditions, by supplying themselves with the luxury of fresh, health-giving fruits from their own gardens, elevating the tone of their living, and at the same time reducing its cost, we shall feel that the labor and expense are insignificant.

Our illustrations are all half-tones from photographs, except the one of a fruiting branch of the Japanese Wineberry. Unless otherwise stated under each, the illustrations are from fruits grown upon the Experiment Station farms. Thanks are due to all those who have generously assisted in the preparation of this report. W. H. Fairfield has aided the writer in the preparation of the subject matter, more especially with the cultural suggestions and tabulations. Hon. J. M. Carey has kindly loaned three of the engravings and furnished data. J. H. Gordon, J. Lund, and J. King furnished fruits from which photographs were made, and G. W. Barlow and C. H. Manning furnished data and three of the photographs. Thanks are due the superintendents of all the farms, and especially J. S. Meyer of Lander, for his untiring energy and kindness in furnishing information regarding his own orchard work.



Red Cherry Currant, Natural Size.

CULTURAL SUGGESTIONS.

The general laws of cultivation of fruits are the same everywhere, but in the arid region, methods of planting and treatment differ materially from those in general practice where irrigation is unnecessary. Those methods which produce best results in adjoining arid states will be found applicable to our conditions, varying somewhat with the locality, soil, exposure, climatic conditions, and water supply. No class of crops will give greater or more satisfactory returns for attention and care bestowed, than fruits. They naturally require intensive cultivation. The most of them have been domesticated for a great many years. They have been nursed and improved to reach their present perfection, and are so far above the wild sorts that they more quickly succumb when neglected. They have been cared for so long that they have lost much of the power of competing with other plants in the struggle for existence. This is undoubtedly intensified when they are brought into conditions differing from those of their original home.

They adapt themselves rather slowly to new conditions, and on this account we believe it always pays to patronize good reliable home nurserymen who have stock raised under like conditions and more or less acclimated, than to buy plants from a distance where they are raised under widely differing conditions. This was illustrated in the sudden storm of September, 1895, which killed nearly all the young trees in the orchards of the state, while only a small percent of the old well-established and acclimated trees died from its effects. Another evidence is that nearly all the strawberry plants which were pot-grown in the east died when set out upon the experiment farms, while a large per cent of hardy out-door plants from western nurseries lived.

While we know of one or two orchards in the state where trees were purchased in the east, we believe our recommendation to plant only western grown trees, or western stock of any fruit a good one, provided that the stock is as good and the varieties wanted can be obtained.

The soils of the state are, as a rule, quite rich in the inorganic plant foods, principally lacking in humus or vegetable mold which supplies nitrogen. However, it will probably be found advantageous to supply fruits, more especially orchards, with some fertilizer rich in potash. Wood ashes will answer the purpose well, where they can be obtained. Barnyard manure is the most perfect fertilizer and should always be used liberally with fruits. Insect enemies of fruits have not yet been reported as doing damage in this state, with the exception of the Codlin Moth, which has made its appearance at Lander. If concerted action is taken, the spread and increase of injurious insects could be largely, if not entirely, prevented. It is important, then, that every one should destroy such pests as soon as they appear. Modern methods of combating these insects by spraying, etc., directions for which are given in recent horticultural publications, should be carefully followed.*

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*Anyone desiring information in regard to methods of spraying, and solutions with which to combat insect enemies or plant diseases, is invited to write to the Horticulturist, Experiment Station, Laramie, Wyoming.

The following brief cultural directions we believe will be found applicable to most parts of the state.

THE ORCHARD.

Deciding on the location of an orchard is an important step. Under our conditions a north slope is preferable, because the snow stays better in the winter, the buds are not apt to start so early in the spring, and the trees are not so liable to become burned on the south and west sides by the bright sunshine during the time that there are no leaves on them. We prefer a well-drained soil, along a stream, with all the protection which can be obtained from surrounding trees, hills, or buildings, especially on the sides from which the prevailing winds blow. The soil in such a locality is not apt to contain enough alkali to be injurious, and where winter irrigation can not be practiced, the bottom lands are not so apt to freeze and thaw often, or dry out. When given proper care, however, orchards will succeed well on uplands. Plant windbreaks of cottonwoods and willows on the side or sides from which the prevailing winds blow.

The soil should be thoroughly prepared, manured, plowed, and if possible, subsoiled, and harrowed. It is generally better to set the trees in rows both ways, but on steep slopes it is sometimes necessary to plant one way, following the contour lines, so that the land may be irrigated without washing. We recommend buying trees in the fall, heeling them in over winter and planting in the spring. Heel them in in a place where the soil is not apt to dry out or blow away, and cover roots,stems,and branches with soil. Lay the trees well apart, for if they are placed in bunches, open spaces are apt to be left among the roots and stems, harboring mice or other rodents, which gnaw the roots and bark, either greatly injuring or entirely destroying the trees. A number of trees were destroyed in this way at Lander.

There is some diversity of opinion as to the distance apart trees should be planted under our conditions.. Some claim that many orchards are running out in the West before they should, because the trees are set too close together. We think good distances are twenty-five feet each way for apples, eighteen or twenty feet for crabs and pears, twelve or fifteen feet for cherries and plums. The branches should not be allowed to touch or interlock when the trees are full grown.

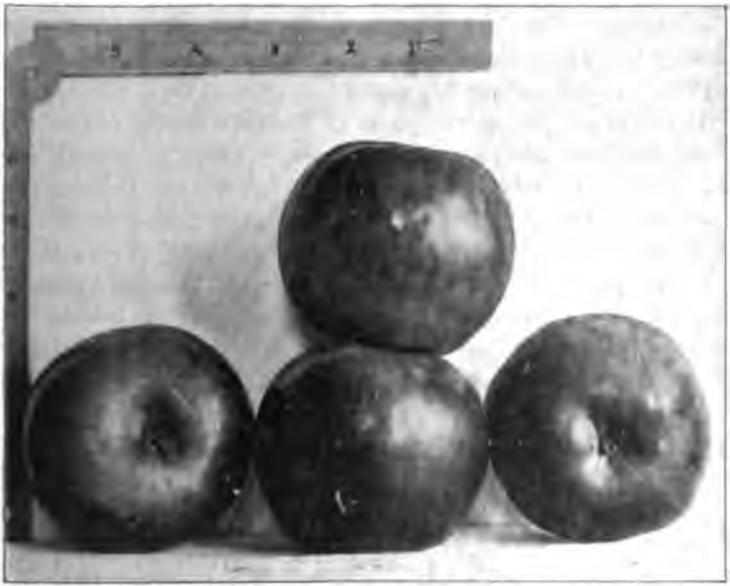
In digging holes in which to set trees, make them large enough to accommodate the roots without twisting or bending them. If hard-pan is reached, it should be broken up around where the tree is to be set, using blasting powder, if necessary. Set trees the same depth in the ground as they were in the nursery rows. We think the surest way to make trees grow is to cut back the tops judiciously, place enough loose soil in the hole to cover the roots and hold them in place, working it in around them closely, and then fill the hole with water. After the water has soaked away sufficiently, finish filling the hole even with the ground, tramping it firmly around the trunk. Planting with water in this way is generally better than puddling the soil, which is apt to be injurious if the soil contains much clay.

The best age to set out is probably two years from the graft. We like trees which are headed low, i. e. from two to three feet from the ground. In starting the head with young trees, avoid making crotches or pruning too much. Pruning is always in order. The sooner limbs or branches which are not wanted are cut off, the less strength they will take from the tree.

We have seen some fruit and shade trees so disgracefully pruned, that it calls for a word of protest here. In amputating the limb of a man, it may be wise to take it off as far from the trunk as possible, but in pruning trees, always pursue exactly the opposite policy. Many make a practice of cutting off limbs two or four inches from the trunk or main branch, which makes stubs that die and leave behind a diseased place or ugly scar. Whenever a branch or limb is removed, it should be cut off as close to the trunk or branch upon which it groes as possible, making a smooth cut over which the bark will grow and heal the wound. In cutting back the tops of trees, we prefer to make slanting cuts with a sharp knife or ax rather than sawing the limb squarely off. In cutting back top limbs, cut off just above a bud or limb, so there will be little or none of the branch left which will die below the cut. Any severe pruning of the apple should be done in the spring before the buds swell. Cherries and plums should be pruned in the summer, for, if they are cut at other seasons, gum exudes from the wounds. Summer pruning should never be severe, but should consist in rubbing off buds which are developing where they are not wanted, and pinching back slender limbs to increase fruitfulness and make a well formed tree.

Give the orchard clean cultivation. Never allow weeds to grow and give the surface of the soil a shallow cultivation often. We do not recommend planting any kind of grass in the orchard. If crops are raised on the land between young trees, they should be planted some distance from them and should consist of some hoed crops which require shallow cultivation and do not grow tall enough to shade the trees. Good crops for this purpose are beans, peas, squashes, pumpkins, and melons. Rows of currants and gooseberries may be planted between the apple rows, but such fruits as raspberries are not so good, as they grow tall and require so much digging for their winter protection that the roots of the trees are apt to be injured.

It pays to give trees winter protection. Place a good heavy mulch of barnyard litter around each tree, taking care not to let it come directly against the trunk, to heat or harbor insects or mice which will injure the bark. Our jack rabbit is also fond of gnawing the bark of trees. Shoot the rabbit, and protect the trees with some mechanical device such as wire screen, or better still, some form of slat protectors. It is better to place the mulch around the trees after the first snow storm, as it will hold the moisture and guard somewhat against alternate thawing and freezing. Wrapping the trunks of the trees with burlap and then with paper, tied on securely, will prevent their sunburning and largely check the transpiration of moisture. A board, or better, two boards nailed together, forming a right angle, and set on the south and west of each tree, will keep the trunk from becoming sunburned.



Wealthy Apples, Laramie, 1897. Raised by J. Lund.

SMALL FRUITS.

STRAWBERRIES.—New beds may be planted either in the spring or late summer. If planted in late summer or fall, do it as early as good thrifty young plants can be obtained for the purpose. Strawberries are of easy culture and will grow almost anywhere, but they well repay every advantage given them. Have the soil well manured and thoroughly pulverized. Plow the manure into the soil six months or a year before the plants are set, and have the land as free from weeds as possible. Set the plants in rows three or four feet apart and place them one foot apart in the row. The quickest and surest way to plant is to plow straight, narrow furrows for the rows, run water enough through the furrows to soak them up well, and have the plants dropped the proper distance apart along the edge of the furrow. The one who spreads the plants is followed closely by the planter, who takes up the plant in one hand, takes a handful of muddy soil from the edge of the furrow with the other, places the plant in the hole made, and at the same time spreads the roots and covers them almost in one motion. In this way a man who is quick and skillful can plant an acre a day and do it well. In clay, however, it may be found that this method will puddle the soil enough to retard the growth. The furrows can be left open a few days and water run through every day or two until the plants are well established, when a new furrow should be plowed, filling up the old one.

Give the plants careful attention the first season. Irrigate in the fall, and as soon as the ground is frozen, mulch heavily with clean straw or other litter that is as free from weed seeds as possible. Hold the mulch in place with poles, brush, or other weights. In some parts of the state it may be found advantageous to cover the plants with earth instead of other mulch. Sometimes a light mulch of pine needles or straw is left around the plants in the spring to keep the berries clean, but with ordinary mulching material this will not be feasible, and in any case it is apt to interfere more or less with irrigation. Recently much discussion has taken place in regard to the length of time a strawberry bed should be maintained. Many contend it is more profitable to allow a strawberry bed to fruit only one year, renewing it every second year. With small beds such as will ordinarily be planted in this state, where well cared for and kept clean, we think that they may be maintained three or four years.

RASPBERRIES, BLACKBERRIES AND DEWBERRIES.—In planting these fruits plenty of room should be given, so that they may be easily covered with earth for winter protection. A letter from J. S. Meyer of Lander says:

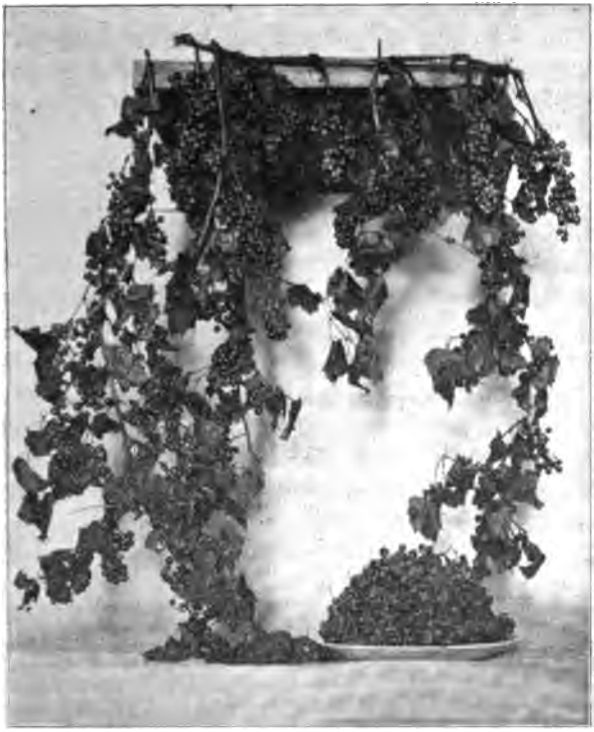
"In planting our small fruits, we laid out rows, five feet apart for raspberries, blackberries, and dewberries, and planted them four feet apart in the rows. I find we got our berries all too close. If I were to set out anything like one-fourth acre or more to these fruits, I would have the rows seven feet apart and plant some vegetables between them the first year or two. In order to cover the canes easily with earth, it is better to have the rows wide."

The soil should be prepared in the same way as for other fruits, and cultivated often, at least after each irrigation. To insure their maturing and to increase their fruitfulness, the tips of the new canes should be pinched back after they reach a sufficient height in August, at which time, also, the irrigation should cease. After the old canes are through fruiting, cut them all out, and remove enough of the new canes to thin them properly, leaving only the stronger ones for next season's fruiting. Irrigate in the fall when the growth has stopped. After the soil has dried out sufficiently, before the ground freezes, lay the canes down lengthwise in the row and cover deeply enough with earth to prevent their drying out through the winter. This can be done on a large scale with little trouble by using a sled, turned up a little in front and smooth underneath, so as not to injure the canes. This is drawn by two horses, one on each side of the row. A few shovelfuls of soil thrown upon the ends of the canes as the sled is drawn over them will hold them down. The covering can be finished by plowing along the sides of the row, throwing the soil over the horizontal canes. They should be uncovered in the spring before the buds throw out new shoots, but not so early that the flowers will come out in time to be caught by the late frosts.

GOOSEBERRIES AND CURRANTS.—These may be placed in rows four or five feet apart and four feet apart in the rows. Give the same preparation of the ground as for other fruits and give clean cultivation. They need pruning, to leave the stems somewhat open and at equal distances apart. As they become old and thicken up, cut out the old crooked and weak fruiting stems, leaving enough two-year-old stems for next year's crop. On account of their hardy character, it is not necessary to give them any winter protection other than a good mulch on the soil to retain moisture.

GRAPES.—We do not attempt to give any but the simplest directions for cultivating grapes in this state. They must be given thorough cultivation. Some writers claim that soil of only moderate richness is better than one which is very rich. The grapes upon the Lander experiment farm are planted in rows five feet apart, four feet apart in the row. We recommend giving them more room than this. Directions for pruning and different methods of training are given in horticultural works and need not be repeated here. The long vines should often be pinched back during the summer to help ripen the wood, and young shoots that are out of place should be rubbed off as soon as they appear. After the leaves are dropped in the fall, the bearing shoots should be cut back, leaving two or three strong buds.

As it is necessary to lay the vines on the ground and cover with earth for the winter,in the same way as with raspberries and blackberries, it is necessary to build the trellis and train the vines to it in such a way as to interfere least with this operation. Where the grapes are to be extensively grown, a low trellis of wire stretched between posts a considerable distance apart and supported between the posts



NATIVE GRAPES.
Collected in North Platte Canon by A. Nelson.

by stakes which are easily removed, is best. The vines can be easily taken down in the fall, the wire removed and the vines covered with a plow. Finish with a shovel, to insure their all being well covered. Grapes succeed best on soil with good natural drainage, along streams or near bodies of water, and where they can be protected by windbreaks. It is doubtful if they will succeed at high altitudes in this state, but at lower altitudes wherever the native grape is found, early and hardy varieties succeed if given proper cultivation and care.

IRRIGATION OF FRUITS.

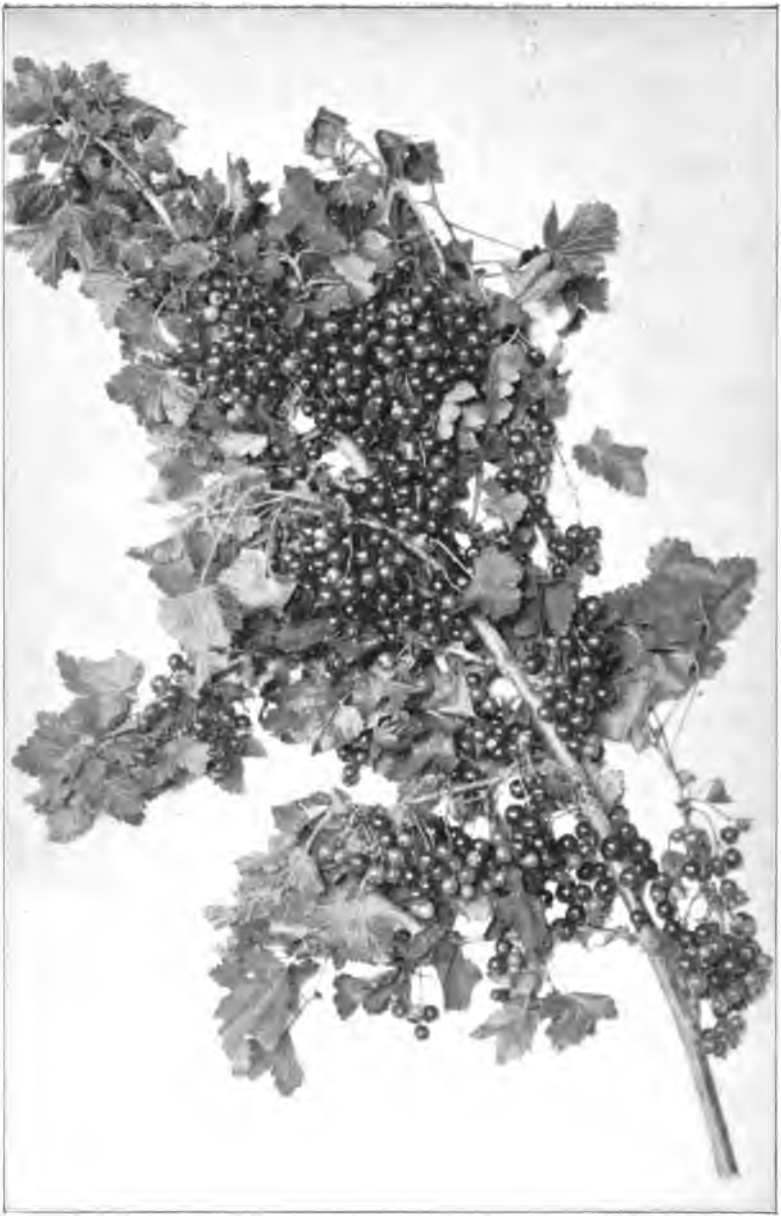
Irrigation is one of the most important factors in the success or failure of fruit raising. An unirrigated region cannot compete with an irrigated one in the yield or quality of the crop. This is true of fruits to a greater extent than of any other class of plants. Directly proportional to the judicious application of water will be the success of the crop. We believe that a large percent of failures is attributable to careless irrigation and over-irrigation. The effects of water on soil and fruits must be carefully studied by the cultivator who would succeed.

Furrow or seepage irrigation is the system which should be followed. With the exception, perhaps, of strawberries, it may be generally stated that flooding is not advisable for any of the fruits we raise. Irrigating furrows should never have so great a fall as to wash the soil. Their proximity to the plants should depend on the absorbing power of the soil, the character of the subsoil, and somewhat upon the age of the plant. Water should never be allowed to touch the stems or trunks of shrubs or trees. Each irrigation should be thorough, and as the water is generally cold, should be finished as quickly as possible. If the water stands for any length of time around fruits, so that the ground remains saturated, great injury and retarding of growth will result. Fruits should not be made to drink more water than they actually need. The amount required depends on the character and slope of the soil and subsoil, the condition of the weather, the kind of fruit, whether in bearing or not, and the season. Each irrigation should be followed by a thorough cultivation as soon as the soil is dry enough to be properly worked. During the early and middle part of the growing season, irrigation should occur often enough to keep the ground in a moist condition, but not wet. This is more essential during the bearing season for small fruits. During the latter part of the season, as a general rule, after the middle of August, irrigation should be stopped, so that the plants will cease growing rapidly, and have an opportunity to ripen their wood and develop buds. Late in the fall, before the ground has frozen, and when growth has ceased, the land should be thoroughly irrigated. The later this irrigation can be done the better, as the object is to store moisture in the soil sufficient for winter.

As we have before indicated, in the state papers, where orchards are planted on bottom lands that have a continual supply of moisture, fall irrigation may be unnecessary. But on upland it is the surest way to prevent trees from winter-killing, and when possible, irrigations through the winter will be found advantageous. Directly after the last fall irrigation, or after the first snow-fall, a heavy mulch will tend to prevent evaporation and sudden changes of temperature and hold the frost in the ground later in the spring, thus retarding a too early flow of sap. This is of great importance with us, as our open winters and warm spring days are apt to bring out the blooms in time to be destroyed by late frosts.

Strawberries may be flooded, if the rows are so well matted as entirely to shade the ground, but during the fruiting season the berries are apt to be soiled, occasioning considerable loss. When in fruit they require considerable water. We have found it a good plan to pick the berries every other day, and irrigate every fourth day, or irrigate the day they are picked.

SUB-IRRIGATION.—As the word implies, this is furnishing water from below the surface. It is accomplished by laying pipes or tiling in the ground, with openings such distances apart as will allow the ground to be kept moist. The distance between the pipes and that between the openings in them, when they are used for small fruits, should depend on the character of the soil and the subsoil. In orchards pipes are usually placed along each row with an opening near each tree or between two trees. We have experimented with sub-irrigation for shade trees and believe it to be a great improvement over open ditches when once established. The great objection to this method is the first cost, which is too great, unless the land is very valuable and valuable crops are to be grown. Where porous tiling is used, unless it has to be shipped from a great distance, a system of sub-irrigation, where the soil is such that pipes can be placed twenty feet apart, will cot $300.00 an acre. Its advantages are entirely doing away with open ditches; effecting an economy in water, unless the subsoil is too porous; reducing the expense of applying water, as it requires no labor except turning the water on and off; applying the water from below in the natural way, thus preventing the cooling effects of evaporation as well as the baking of the surface soil. Each grower must decide for himself whether or not it possesses advantages for his farm sufficient to warrant the outlay.



RED CHERRY CURRANT. Raised by J. King, Laramie, 1897.

LARAMIE.

ALTITUDE, 7,200 FEET.

Very few have had sufficient faith in the possibility of growing even the hardiest kinds of fruit upon the Laramie Plains to give the matter more than a passing thought. A few, however, have boldly hazarded their time, labor, and money,and their success has been worth many times the trouble and cost. The fact has been demonstrated that even under our conditions of altitude and climate, hardy varieties will succeed, if they are properly cared for and given shelter from the drying winds of the winter season. Our work with fruit upon the experiment farm has given us little to report. As a rule the results have been negative rather than otherwise. We have planted a great number of kinds and varieties in the hope that some might be found which would succeed without the protection of wind-breaks and winter irrigation.

The Station farm is situated upon the open plain, without any object that will break the force of the winds. From six to eight months of the year the farm is without water with which to irrigate, and the soil becomes so dried out that few plants can survive in it. However, under these conditions, our hardy apple trees, such as Siberian Crabs and Ben Davis, lived through three seasons, and some varieties of small fruits have borne. The following is a brief report upon those kinds and varieties fruited, arranged in order of their hardiness:

CURRANTS.

Of the varieties that have been grown, the Red Cherry, White Grape, and White Dutch have been fruiting each year. One black variety, namely, Lee's Prolific, has succeeded fairly well, and the Crandall produced vigorous vines, but only a small amount of fruit.

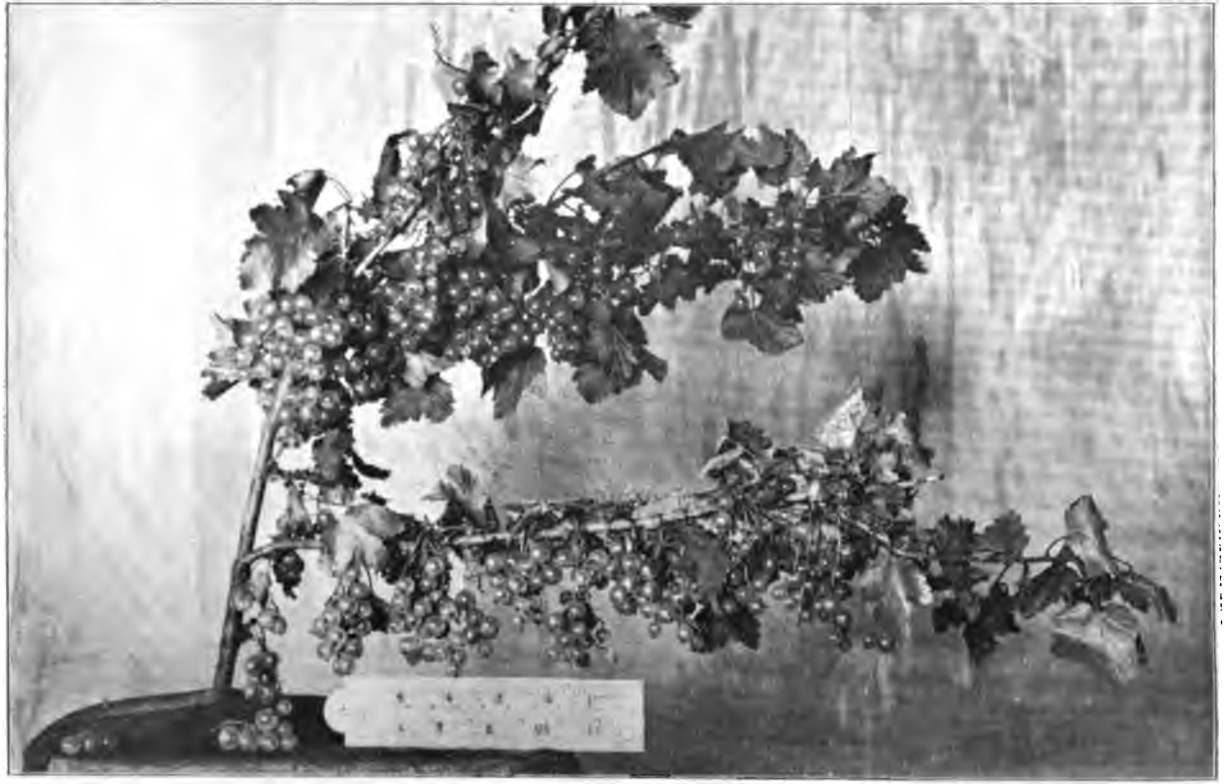
DEWBERRIES.

Of a large number of varieties of blackberries, raspberries, and dewberries, the Lucretia Dewberry has proved the most hardy. All the other plants winter-killed. The few vines of dewberries were given almost no attention after the first season. With a comparatively small amount of irrigation, they have lived through the winter and ripened some fruit. We have no doubt that, where they are given some protection, they will prove very successful.

STRAWBERRIES.

A large number of varieties of strawberries was planted in the spring of 1892. The plants were obtained from different nurseries in the United States, some being pot-grown plants which had been raised in the greenhouses of the east. Not only here, but in other parts of the state as well, the pot-grown plants seemed too tender, and were the first to succumb. The plants obtained from the Colorado nurseries seemed more hardy and lived longer than the others.

An experiment to determine the best method of winter protection was carried out during the winter of 1892 and 1893. One-third of the plants of each variety was left uncovered, one-third was covered with straw and litter, and one-third was covered with earth. The water in the soil dried out and nearly all of the plants died. Only a few of those covered with soil came out alive in the spring and these died later. In 1896 a new experiment with strawberries was begun. Four varieties were planted about August 20, and were irrigated late in the fall and covered with coarse litter. About one-half of the plants died during the winter,



WHITE GRAPE CURRANT. Raised by J. King, Laramie, 1897.

but the others have grown well this summer, and the Vick and Warfield have ripened fruit. We believe the strawberry industry will meet with success where the plants can be irrigated sufficiently in the winter and have some protection. It should be profitable to raise them for market here, as they will ripen late in the season, after all other berries are out of market. Its season will be from two to three weeks later than that of other places where strawberries are raised for shipment. In town and on ranches along streams, some of our people are successfully growing strawberries for their own use.

GOOSEBERRIES.

While no gooseberries have fruited, with the exception of a very few berries on one variety during one season, the vines lived through the winter without other protection than a light mulch. The varieties which seemed most hardy were Houghton, Industry, Charles Downing, and Golden Prolific.

Fruit Notes on the Laramie Plains.

A few ranchmen on the Laramie Plains have attempted to raise fruits with varying success. In the winter of 1891-92, Mr. E. S. R. Boughton of the northern part of Albany county, stated that all the fruit trees planted in that section had died. In many sheltered localities there are fruit trees now growing and some of them are bearing creditable crops. In sheltered yards in Laramie a number of people have succeeded in growing hardy apples. Hon. Edward Ivinson has a number of fine trees of standard sorts in his yard and some of them have matured fruit. Judge M. C. Brown has two fine Siberian Crab trees which have borne heavy crops for a number of years. We present a cut of one of these trees. Hon. Otto Gramm has some fine trees, and Mr. Ora Haley has succeeded in ripening some apples in his yard.

Outside of town, on many of the ranches, are sheltered situations where hardy tree fruits will succeeed. We know of only one ranchman, however, who has trees now bearing fruit.

MR. LUND'S SUCCESS.

Mr. Jacob Lund, whose ranch is situated 25 miles from Laramie on the Big Laramie river and near the mountains, has given fruit raising attention in a small way. Five years ago he purchased some two year old apple trees from a Colorado nursery and planted them on bottom land. Timothy was planted among the young trees and the second year the grass grew so high as to shade and greatly injure the trees. He states also that the trees were injured by being kept too wet, for in addition to the moisture on the bottom land they were irrigated freely, the ground having been kept soaked with water. The trees have been given no winter protection, but they have grown well and are now bearing nicely. When five years old one tree bore a single apple; last year this tree had six small apples on it, and this year the same tree bore forty fine, large apples, which ripened. On October 20 Mr. Lund brought four of these apples to the University. As he could not state the variety, one of them was sent to Prof. L. H. Bailey of Cornell University, who, with other experts, examined it and reported it to be a Wealthy. We show cuts of these apples, both natural size, and smaller taken with a scale to show the size. Mr. Lund has also ripened a few cherries (probably Morello) and has some thrifty plum trees. He has met with considerable success in raising strawberries and currants. He stated that his family could not afford to purchase fresh fruit from the markets and never knew what the luxury meant until his

UNIV. OF

WHITE GRAPE CURRANTS. Natura Size.
Raised by J. King, Laramie, 1897.

SIBERIAN CRAB. Laramie, 1891
Raised by M. C. Brown.

strawberries came into bearing, after which they had all the fruit they could use. Mr. Lund practices fall irrigation. Water is kept away from the tree and other fruits during the fall while they are ripening their wood. After everything begins to freeze and the leaves have fallen from the trees, they are thoroughly irrigated to keep them from drying out during the winter.

SMALL FRUITS.

A number of our ranchmen have raised small fruits. Mr. James King, whose ranch is 18 miles west of Laramie, has raised remarkable crops of the White Grape and Red Cherry currants. Illustrations of these, made from photographs, are shown. The fruit is used principally for making wine and jelly.

Mr. A. S. Foster, who has a ranch in the Centennial valley, has raised abundant crops of strawberries and raspberries. He has informed us that he has plantations of the wild varieties of raspberries and strawberries which have produced excellent crops.

LANDER.

The town of Lander is situated in the fertile valley of the Big Popo Agie river, and is at an altitude of about 5,300 feet. It is surrounded by a farming country well adapted to the production of fruits. The nearness of the Wind River mountains to the arable land of the valleys gives it protection from the winds and cold. The streams from the mountains give abundant water supply. The water is very pure, containing almost no salts of any kind.* On account of the water being so cold and abundant, seepage or furrow irrigation is generally practiced for all crops.† The soil of the bottom lands along the streams is black alluvial deposit, while that of the bench lands‡ is red sandy loam which is of great depth, there being no apparent distinction between the surface and sub-soil. In both the Big and Little Popo Agie valleys farmers have been producing hardy fruits for a number of years, and in sufficient quantity to remove all doubt as to their adaptability to the soil and climate of that region.

Fruits Upon the Experiment Farm.

From the fruit experiments upon the Lander farm we have obtained some data of value, which, with the experience of farmers of that region who are growing fruit, enable us to state with considerable accuracy what may be done in fruit growing in that section. The farm of the sub-station, located six miles west of Lander at an altitude of about 5,500 feet, was established in 1891. In the spring of 1892 as ex-

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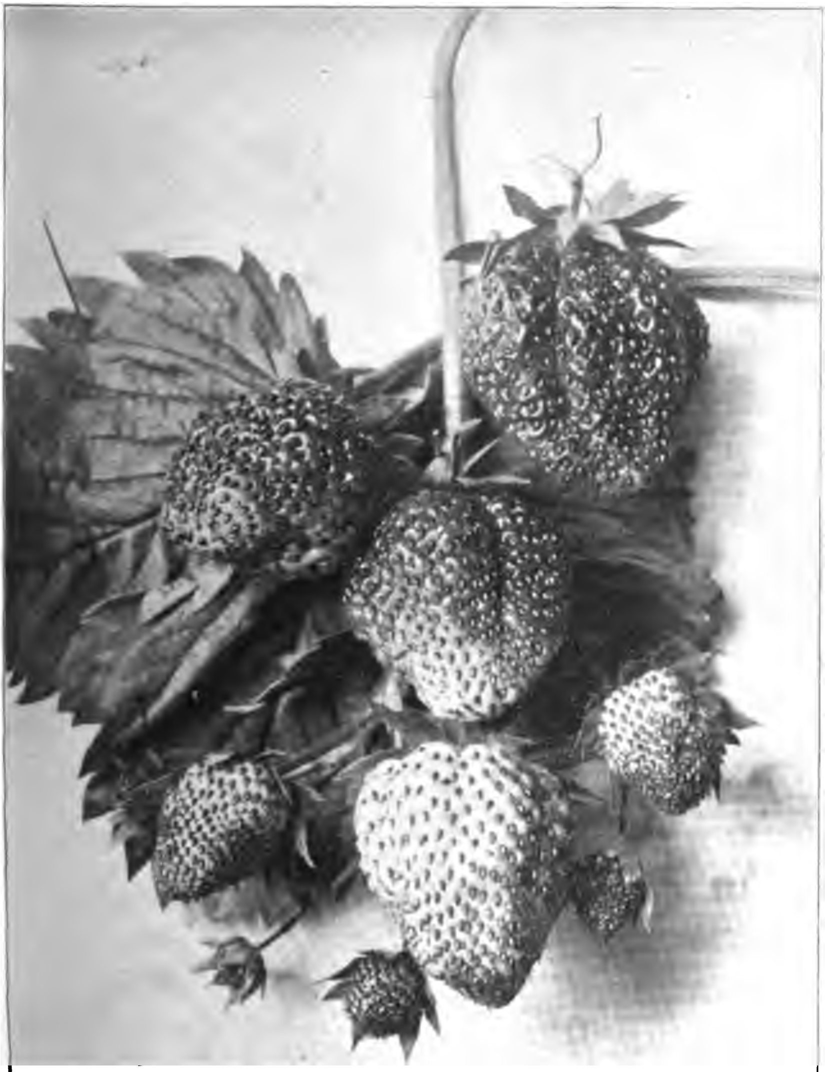
*See Bulletin No. 24, Water Analyses, page 119.

†See Bulletin No. 8, page 19.

‡See Bulletin No. 6, page 17, and Bulletin No. 14, page 108.



CHARLES DOWNING STRAWBERRY, Natural Size. Lander, 1897.

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tensive plantings of fruits were made as available funds would allow, and these have been increased to some extent by plantings made since. The fruit plats are on the first bench above the river. Most of them have a gentle slope toward the north.

Between three and four acres of fruits have been growing since 1892. The experiments received a severe check in the fall of 1895 and during the following winter. On this account complete reports of all fruits have not been furnished the past two seasons.

ORCHARD FRUITS.

With the exception of a few trees, the young orchard on the experiment farm has not come into bearing. However, we think a report of all the varieties planted, with a brief history of their growth up to the time of the destructive freeze of September, 1895, will indicate something of the hardiness and adaptability of the varieties which have been grown. Our report practically ends with the fall of 1895.

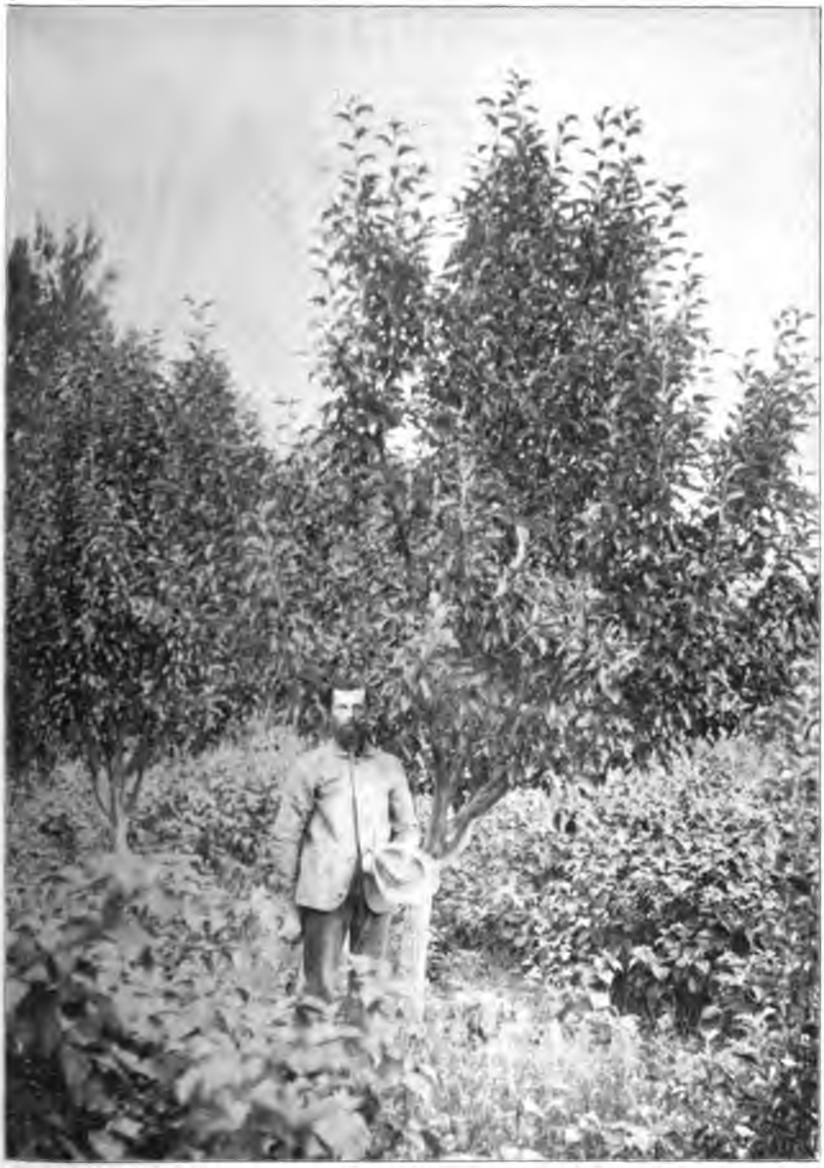
On September 20th of that year, when the trees were still in full leaf, the temperature suddenly dropped twenty degrees below freezing point, and as Mr. Meyer points out in his letter, young trees which had been set out only two or three years were nearly all destroyed. This storm was one of those rare occurrences which occasionally happen in all parts of the country, and which are especially discouraging in a new region where plantings of fruit are just beginning to be made. So destructive was it, that many native cottonwoods and other trees are said to have perished. However, we were fortunate in having orchards in the different sections of the state that had been planted long enough to escape with comparatively little damage. If this were not the case, we should still have no proof that orchard fruits will succeed. We feel sure that they will succeed regardless of any unusual freak of the weather. On account of lack of

funds, the trees killed have not been replaced on the experiment farm.

The first two winters after setting out the trees they were protected by wrapping the trunks with paper and burlap, put on in December. During the second winter, winter rye was grown on the land between the trees and plowed under in the spring. The superintendent states that this so loosened the ground that the soil was put in better condition of tilth and that it took up the water much better when irrigated.

Because we attach some importance to the locality from which trees are obtained, in the following report we have indicated the nurseries from which they were purchased. A comparison of the success of eastern and western grown trees, the first year after planting, may be of interest. Sixteen varieties with a total number of one hundred forty-six trees were obtained from Green's nursery of Rochester, N. Y., in the fall. They were received in good condition, pitted for the winter, and set out in the orchard in April of 1892. Of the one hundred forty-six trees, fifty-six, that is, about thirty-eight per cent, died the first year. In the spring of 1892 nine varieties, or a total of fifty-two trees, were obtained from Shields' nursery of Loveland, Colorado. These trees were taken up in the spring, boxed in the usual way, and shipped to Lander by freight. On account of the long distance from the railroad, these trees were over a month on the road, and the superintendent reported them in very bad condition when received. Some of them were so far advanced that when the box was opened they were found in blossom, and it was June before they were set out in the orchard. Of fifty-two trees planted, nine, or about seventeen per cent, died the first year.

In order to determine whether the different varieties obtained from each place would account for the greater loss of eastern trees, we have compared the three hardy varieties,



BRIAR SWEET CRAB IN BEARING.
Orchard of J. S. Meyer, Lander, 1895.

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Ben Davis, Oldenburg, and Wealthy, which were purchased from both nurseries. Of forty trees of these varieties obtained from New York, thirteen trees, or thirty-two and one half per cent, died the first year. Of eighteen trees of the same varieties from Colorado, three trees, or sixteen and two-thirds per cent, died the first year. To be strictly accurate, the success of trees taken from the nursery and shipped in the fall is not comparable with the success of those taken up and shipped in the spring.

In this case, however, if there is an error from this cause, it does not change the result, but would rather strengthen it. We have reason to believe the difference shown would be much greater than it is, if both had been given the same treatment. The trees obtained in the fall and planted with the opening of spring, ha'd so much in their favor that it was natural to expect a smaller percent of loss.

Under the circumstances, then, the comparison is legitimate, and the conclusions to be drawn from it may be depended upon. They strengthen the belief that western grown trees will succeed better under our conditions than those which are in no wise acclimated.

Apples.

The following varieties were obtained from Green's nursery of Rochester, N. Y., in the fall of 1891. They were heeled in, by being entirely covered with earth. In April, 1892, the trees were set out in the orchard. All the trees were two years old when planted. The roots of some of the trees were injured by field mice, which made their nest in the pit with the trees. The varieties injured in this way are indicated by an asterisk after the name.

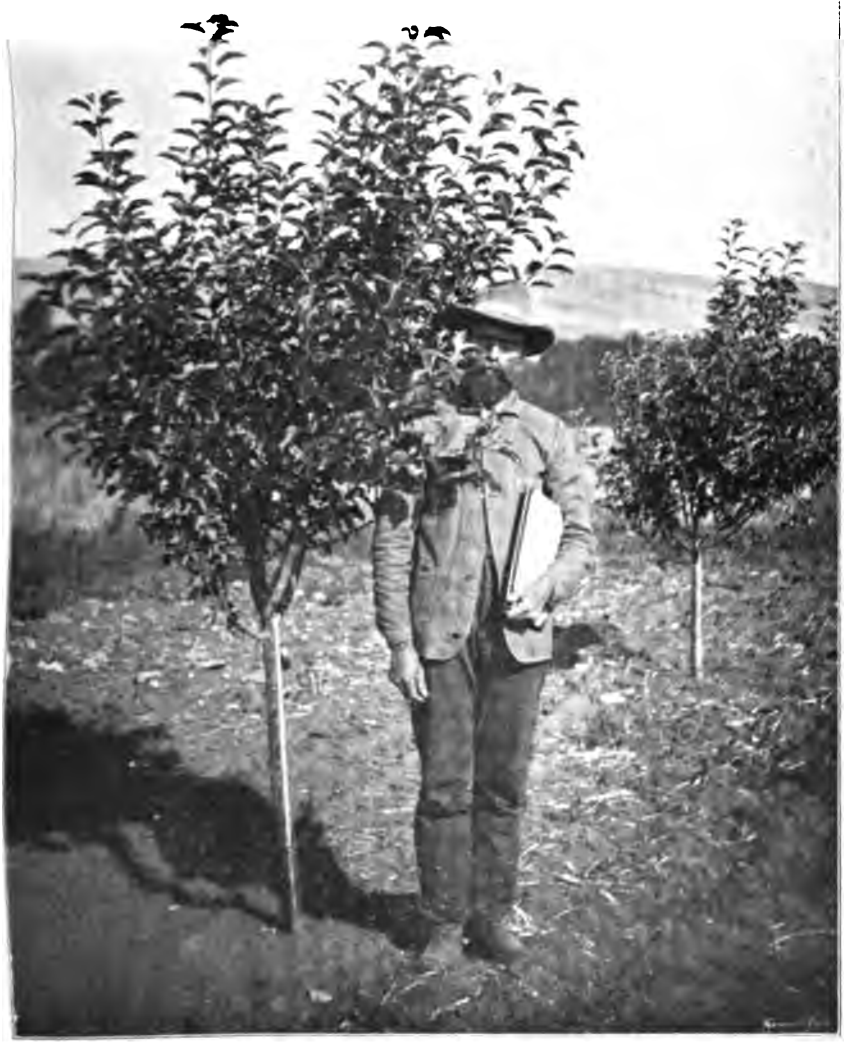
No. planted.	Variety.	Highest trees in fall of 1895.	Remarks.
9	McIntosh Red*	6 ft., 4 in.	Early winter apple.
12	Baldwin*	4 ft., 6 in.	Winter apple, not hardy.
16	Wealthy	8 ft., 7 in.	Hardy, fall apple.
17	Fameuse	7 ft., 9 in	Late fall, apparently hardy.
12	Oldenburg	7 ft., 1 in.	Early fall, apparently hardy.
12	Ben Davis	8 ft., 0 in.	Winter apple. One tree matured an apple in 1895.
9	Yellow Transparent	7 ft., 9 in.	Winter apple.
9	Red Bietigheimer	5 ft., 11 in.	Fall apple.
9	Tetofsky	6 ft., 5 in.	Summer, hardy.
9	Golden Russet	5 ft., 10 in.	Winter, apparently not hardy.
10	Pewaukee	7 ft., 1 in	Winter apple.
9	Sweet Bough	6 ft., 8 in.	Summer apple.
3	Grimes' Golden Pippin*		Late fall; all died.
4	Tallman Sweet*		Winter; all died.
3	Gravenstein*		Fall; all died.
3	Wolf River		Winter.

The following varieties were obtained from O. D. Shields' nursery of Loveland, Colorado, and shipped to Lander in the fall of 1892. They were so long en route that all were much damaged, and were received so late that it was June before they were planted in the orchard.

No. planted.	Variety.	Height of tallest, fall of 1895.	Remarks.
6	Gano	7 ft., 6 in.	Winter.
4	Martha Crab	8 ft., 2 in.	Fall.
6	Whitney Crab	7 ft., 6 in.	
6	Hyslop Crab	7 ft., 8 in.	Fall.
6	Oldenburg	7 ft., 5 in.	Early fall.
6	Ben Davis	8 ft., 0 in.	Winter.
6	Yellow Transparent	7 ft., 9 in.	Winter.
6	Red Astrachan		Summer.
6	Wealthy	7 ft., 7 in.	Fall.

The following varieties from O. D. Shields were set out in the spring of 1894:

No. planted.	Variety.	Height of tallest, fall of 1895.	Remarks.
11	Haas	6 ft., 5 in.	Fall.
5	Pewaukee	7 ft., 1 in.	Winter.
6	Tallman Sweet	5 ft., 9 in.	Winter.
5	Oldenburg	7 ft., 5 in.	Early fall.
4	Hyslop Crab	7 ft., 8 in.	Fall.
6	Utter's Red		Trees one year old, early winter.
8	Golden Pippin		Trees one year old, late fall.
10	Jonathan	5 ft., 1 in.	Winter.
4	Ben Davis	8 ft.	Winter.
5	Walbridge	6 ft.	Late winter.



BEN DAVIS APPLE TREES. Lander, 1895.

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Apricots.

While no apricots have borne fruit, the trees have lived fairly well and made excellent growth. In May, 1892, there were planted two each of J. L. Budd, Gibb, and Alexander, and in June three Russian apricots. Those planted in June were so long on the road that they were probably dead when received. Those planted in May lived through the first winter, the Gibb making the largest season's growth of any tree set out. One of the Alexander apricots was growing well in 1895, having made a shapely tree six feet high.

Cherries.

Five trees were planted in May, 1892, having been obtained from Spear, of Greeley, Colorado. These were Sport Amorilla, so called, and two unnamed. In June six English Morello and six Early Richmond from Shields were planted. As it was so late when they were received, seven of the twelve trees died the first year. The trees which lived of both English Morello and Early Richmond ripened a few cherries in 1893. In the spring of 1894 three trees of the English Morello and four of the Early Richmond were again planted. In 1895 the tallest trees of English Morello were five feet high, and the tallest of Early Richmond were six feet, eleven inches. These two varieties are very promising at Lander.

Pears.

From Spear's nursery were obtained three Gakovska and three Bessemianka, and from Shields' six each of Keiffer, Flemish Beauty, Bartlett, Clapp's Favorite. Those which seem to be the most hardy, in their order, with the height reached by each, are: Gakovska, eight feet, eight inches; Bessemianka, seven feet, two inches; Flemish Beauty, seven feet, nine inches; Keiffer, eight feet, six inches; Clapp's Favorite, seven feet. Bartlett does not seem to be hardy. Three Clapp's Favorite and one Flemish Beauty were also set out in the spring of 1894.

Plums.

The following varieties obtained from Shields' were set out in June, 1892. The trees were three years old.

6 Abundance—Highest trees 4 ft., 8 in.
5 De Soto—Bloomed in 1893; ripened some fruit in 1895; tallest trees, 7 ft., 10 in.; hardy.
6 Weaver—Tallest trees, 6 ft., 3 in.
6 Hawkeye—Tallest trees, 7 ft.

The following varieties from Spear were set out in May, 1892. Most of them were dead, or nearly so, when received.

1 Botan—Same as Abundance.
2 Chabot.
3 Simmons (?) Probably Simon.
1 Simon.
4 Pottawattamie.

From O. D. Shields and set out in spring of 1894:

1 Hawkeye.
1 De Soto.

Of the varieties tried, the De Soto, Weaver, and Hawkeye have proven most hardy.

Quinces.

Two trees each of the Champion and Mammoth quince were planted, but they did not live the first year, and under the conditions, no conclusions can be drawn as to whether they will or will not succeed.

GRAPES.

At the time the vineyard was planted, little confidence was placed in any of the varieties succeeding. Letters from Fremont county stated that all small fruits, with the ex-

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VINEYARD. Lander, 1895.

ception of grapes, would succeed. Some of the varieties are bearing excellent crops and have proved early enough to mature the fruit before the time of frost. The vineyard is located on the first bench above the river bottom. Our illustration gives a very good idea of its appearance in the summer of 1895, which was the second season any fruit was borne.

The vines have been protected through the winter by being covered with earth. The vines are laid down about the 10th of November and uncovered the last of April. They are fastened up to stakes during the summer and given clean cultivation. The record of each variety up to the season of 1897 is given separately.

CONCORD.—Seventy-one vines one year old were obtained from Green's nursery, Rochester, N. Y., and set out in May, 1892. Twenty-five of them died the first year, but the others made good growth. Thirteen vines obtained from Lovett of New Jersey were set out at the same time and all lived. During the second winter fifteen more of the vines died. In the summer of 1894, eleven pounds of fruit matured, ripening from September 15th to 22nd, and were pronounced of excellent quality. In 1895, when the photograph from which the illustration was made for that year was taken, the vines had well-formed bunches of fruit. The grapes were just beginning to ripen September 7th, at the time of the frost. We have at hand no record of the grapes for 1896.

In 1897 the Concord bore heavily, as is shown in our illustration taken this fall. This picture also illustrates the increase in productiveness since 1895. We have no record of the amount produced by each vine or of the number of vines which have lived through each winter since 1894.

WYOMING RED.—Eighteen vines from Rochester, N. Y., were planted in May, 1892. Four of these died the first year and two died the second year after planting. The others made good growth and bore the first fruit in 1894, when four pounds of grapes ripened. In 1895 there were well formed bunches of grapes on the vines, but they did not ripen before the frost killed them on September 7th. We have no record for 1896, but this season they bore heavily, as can be seen by referring to our illustration made from a photograph this year. The Wyoming Red ripens about the same time as the Concord, and these two varieties have been more successful than the others tried. From the two varieties, sixty-five pounds of fruit was harvested this season.

BRIGHTON.—Twelve vines from Lovett were set out in May, 1892. All lived the first season. Seven vines died the second winter, and no fruit was formed in 1894. In 1895, when our photograph was made, a few bunches were formed, but they did not mature. We have no later report upon this variety.

MOORE'S DIAMOND.—Ten vines from Lovett were set out in May, 1892. These lived the first season, but six died during the second winter. A few scattering grapes ripened on September 22, 1894. In 1895 there were some fair bunches of grapes (see illustration) but they did not mature.

DELAWARE.—Twelve vines from Lovett were planted in May, 1892. None died the first season, but the second winter nearly all died, as they were not covered deeply enough with soil to keep them from drying out. In 1895 there were well formed bunches of grapes, as shown by illustration. These did not fully mature, but were ripening at the time of the frost, September 7th. The variety has not been reported upon since 1895.

MARTHA.—Thirteen vines from Lovett were planted in May, 1892. These lived the first season, but most of them died during the second winter, as they were not covered deeply enough. In 1895 the vines left set a few bunches of

CONCORD GRAPE. Lander, 1895.

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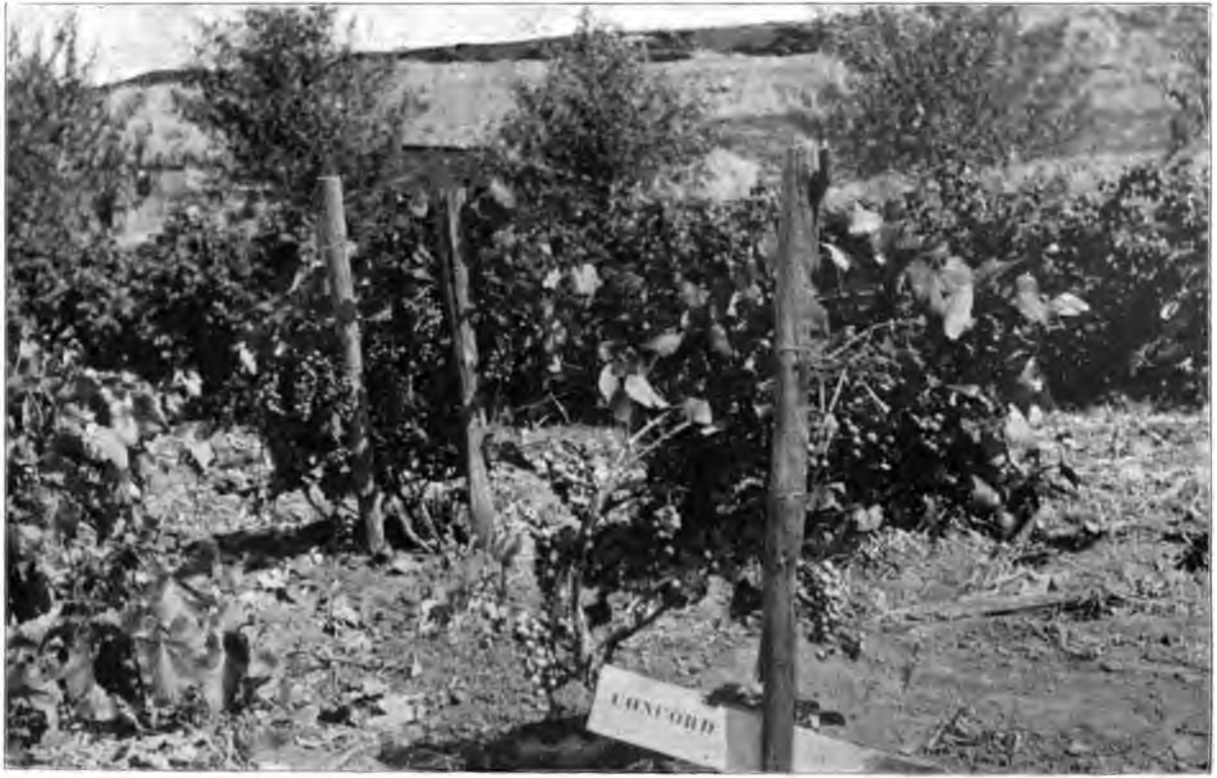

CONCORD GRAPES. Lander, 1897

Photo by Scott.

WYOMING RED GRAPES. Lander, 1897

Photo by Scot

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DELAWARE GRAPE. Lander, 1895.

BRIGHTON GRAPE. Lander, 1895.

MARTHA GRAPE. Lander, 1895.

MOORE'S DIAMOND GRAPE. Lander, 1895.

JAPANESE WINEBERRY. Lander, 1895.
(Illustration was first published in "American Gardening")

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grapes (see illustration) ,but these failed to ripen before frost. This variety has not been reported since 1895.

GREEN MOUNTAIN.—Seven vines from Lovett were planted in May, 1892. These lived through the first year, but all died the second winter because they were not covered deeply enough.

SMALL FRUITS.

Blackberries and Dewberries.

The first three varieties of blackberries given in Table I were obtained from Peter Henderson, New York; numbers four to eight, inclusive, from Lovett, New Jersey, and number nine from Shields, Colorado. The Dewberries were obtained from Shields, Colorado.

In Table III, those varieties of blackberries with an asterisk following their names were frosted on September 7th while much of the fruit was still green. The last three varieties, of which the yields are not given, produced some fruit, but the frost prevented the greater portion of it from maturing.

Table IV gives the results in 1895 with the dewberries. Both varieties produced large, fine fruit, but the Mammoth is the most prolific. Of the varieties of blackberries tried, the Early King and Stone's Hardy are best. Our illustrations show the character of the fruit. None of the varieties produced large yields until the third season after planting.

TABLE I.—*Blackberries, Lander, 1894.*

No.	Variety.	Date set out.	No. set out.	No. died first year.	No. died second year.	Date first ripe in 1894.	Remarks.
1	Wilson, Jr . . .	May, 1892	24	. . . .	9	Aug 5	Berries large, canes stiff.
2	Erie.	" "	13	. . . .	4	Aug. 13	
3	Lawton	" "	16	12	1	No fruit	Not hardy.
4	Lovett's Best .	" "	7	. . . .	1	Aug. 8	Good quality.
5	Child's Tree . .	" "	6	. . . .	4	"	A few berries.
6	Early King . .	" "	26	. . .	6	July 23	Earliest.
7	Early Harvest .	" "	26	. . . .	16	No fruit	
8	Stone's Hardy.	" "	12	2	4	Aug. 8	Very prolific.
9	Kittatinny. . .	June, "	7	. . . .	4	"	

TABLE II.—*Dewberries, Lander, 1894.*

Variety.	Date set out.	No. set out.	No. died first year.	No. died second year.	Date first ripe in 1894.	Remarks.
Lucretia	May, 1892	13	11	....	July 12.	A few berries.
Mammoth	" "	12	9	....	"	Very large.

TABLE III.—*Blackberries, Lander, 1895.*

Variety.	In bloom.	First ripe.	Last picked.	Yield per acre in quarts.
Early King	June 12	July 24	Sept. 25	1278
Wilson Jr.*	" 22	Aug. 14	" 7	524
Stone's Hardy*	July 4	" 23	" "	1118
Lawton*	June 25	" 5	" "	.....
Erie*	" "	" 20	" "	.....
Lovett's Best*	" "	" "	" "	.....

TABLE IV.—*Dewberries, Lander, 1895.*

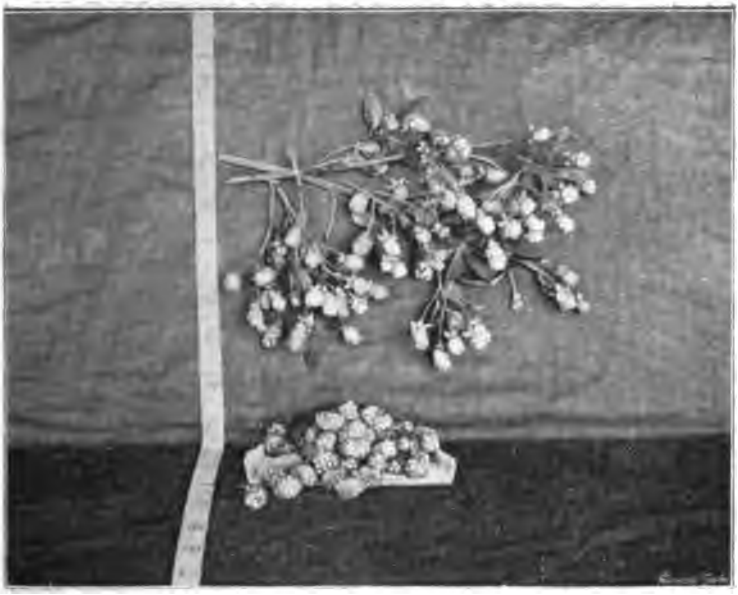
Variety.	In bloom.	First ripe.	Last picked.	Yield per acre in quarts.
Mammoth	June 22	Aug. 8	Sept. 5	2023
Lucretia	" "	" 5	" "	1231

Currants.

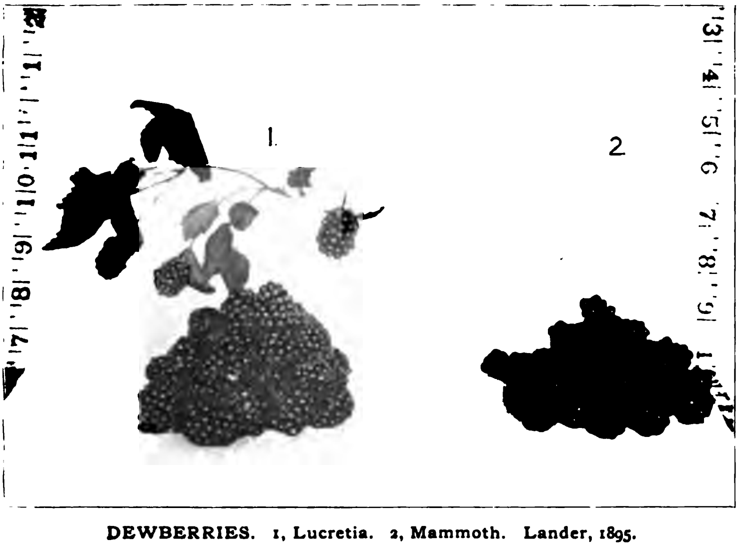
The following varieties obtained from Lovett were set out in May, 1892. None died the second year.

	No. planted.	Died first year.	Age of plants.
White Grape	24	0	2 years
Red Cherry	31	7	1 year
Lee's Prolific	24	1	2 years
Holland	12	0	1 year
Black Naples	12	0	1 year
Crandall	27	2	2 years

In 1894 the White Grape, Red Cherry, and Lee's Prolific bore fruit. The White Grape was very productive, ripening June 30. The Red Cherry was ripe July 12. The "crickets," (a species of grasshopper belonging to the genus Anabrus) which were so destructive in 1894 in the Lander valley, destroyed the larger part of the fruit of the White Grape cur-



CRYSTAL WHITE BLACKBERRIES. Lander, 1895.



DEWBERRIES. 1, Lucretia. 2, Mammoth. Lander, 1895.

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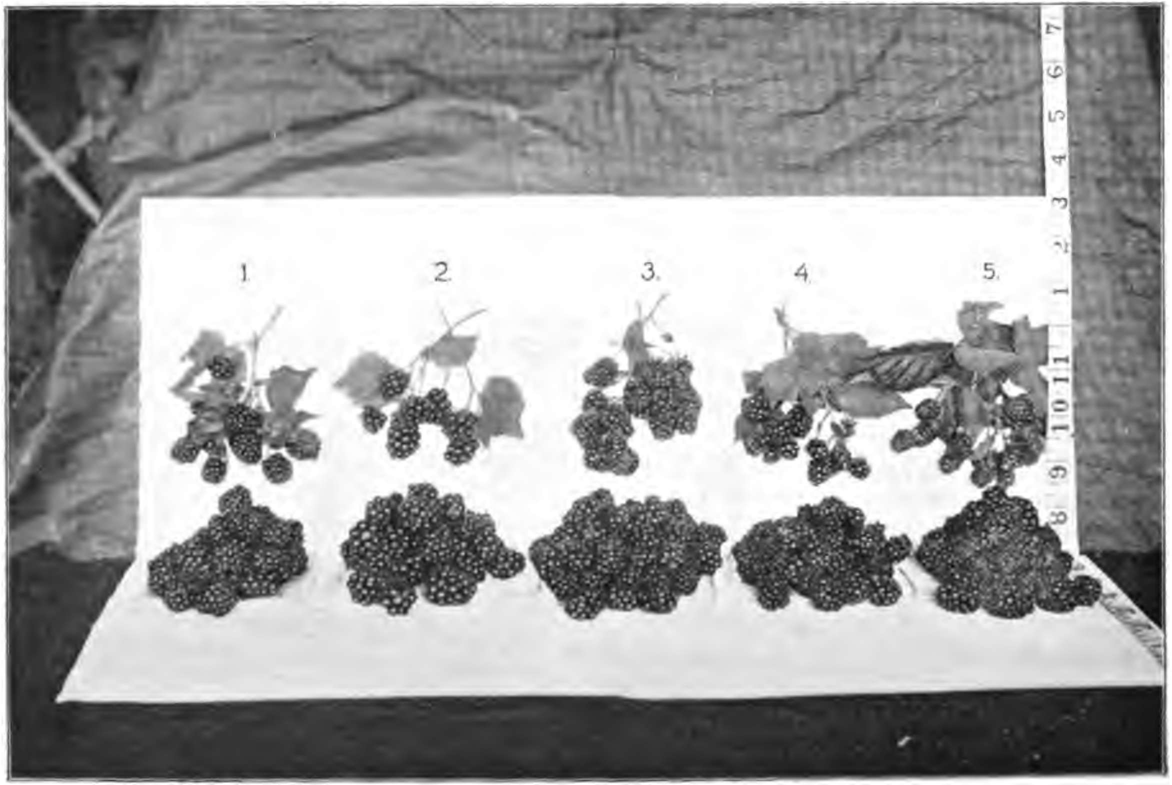

BLACKBERRIES. 1, Erie. 2, Wilson Jr. 3, Stone's Hardy. 4, Lovett's Best. 5, Child's Tree. Lander, 1895.

rants. The strong flavor of Lee's Prolific prevented the crickets from bothering them.

Following is a report upon each variety fruiting in 1895:

HOLLAND.—This is similar to the old White Dutch. The fruit is white and transparent. It was all ripe and picked July 17th. The crop was not heavy, the yield being at the rate of 2722 quarts per acre.

WHITE GRAPE.—Fruit was ripe and harvested July 18th. Berries are white, transparent. This variety gave the heaviest yield, producing at the rate of 11,570 quarts per acre.

RED CHERRY.—Berries are large and red. They were ripe and harvested on July 19th. This variety yielded at the rate of 7260 quarts per acre.

LEE'S PROLIFIC.—The berries are large and black, with a strong odor and flavor unpleasant to many. They were ripe and harvested July 25th. The yield was at the rate of 4310 quarts per acre.

BLACK NAPLES.—This variety is much like Lee's Prolific, the berries having much the same odor and flavor. They were harvested July 25th, and yielded at the rate of 1533 quarts per acre.

Gooseberries.

DOWNING.—Twenty-four plants obtained from Lovett's nursery of New Jersey were planted in May, 1892. The plants were one year old when set out. Six of the number died the first year. In 1894 some fruit was produced, which was ripe by July 20. In 1895 the berries were harvested August 13. The yield was at the rate of 13,159 quarts per acre. The berries are light green when ripe, large, and of excellent quality. The bushes have proved to be hardy and prolific. The superintendent says "this is the gooseberry to grow for profit." The illustration of this variety shows branches loaded with fruit, some of the berries measuring nearly three-fourths of an inch in diameter.

GOLDEN PROLIFIC.—Six one-year-old plants were obtained from Lovett and set out in 1892. One of them died the first year. On July 20, 1894, some fruit ripened. The berries were very large but the bushes made poor growth.

SMITH'S, INDUSTRY, AND HOUGHTON.—Twelve of each of these varieties were obtained from Spear of Colorado and were planted in May, 1892. Nearly all of them died the first two years and none of them succeeded. As the last two have been hardy in other parts of the state, we think they should be given further trial.

Raspberries.

No fruit was obtained until the season of 1894. Those which died during the previous winter, as indicated in the table, were not covered deeply enough with earth to save them. Miller's Daily and Mammoth Cluster did not grow after being set out. Of the red varieties, the Turner and Hansel are best. They are both prolific and of good quality. Early Prolific was the earliest and most prolific variety, but the berries are not of so good a quality, as they crumble when picked.

Among the blackcaps, the Lovett was earliest, and a very good cropper. Kansas and Progress were most prolific and Gregg one of the finest in quality.

The Golden Queen and Caroline, which are yellow varieties, seem much alike, as shown in the illustration. We distinguish no difference in time of blossoming, time of ripening, length of fruiting season, color, quality, or appearance of the canes. However, the Golden Queen has seemed more thrifty and has been more prolific than the Caroline. Some of the varieties which died from being insufficiently covered in winter will undoubtedly prove of

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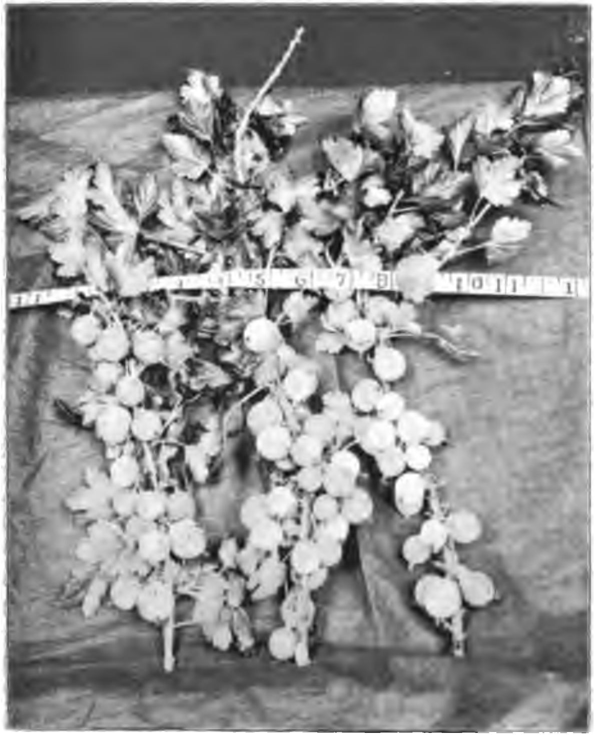
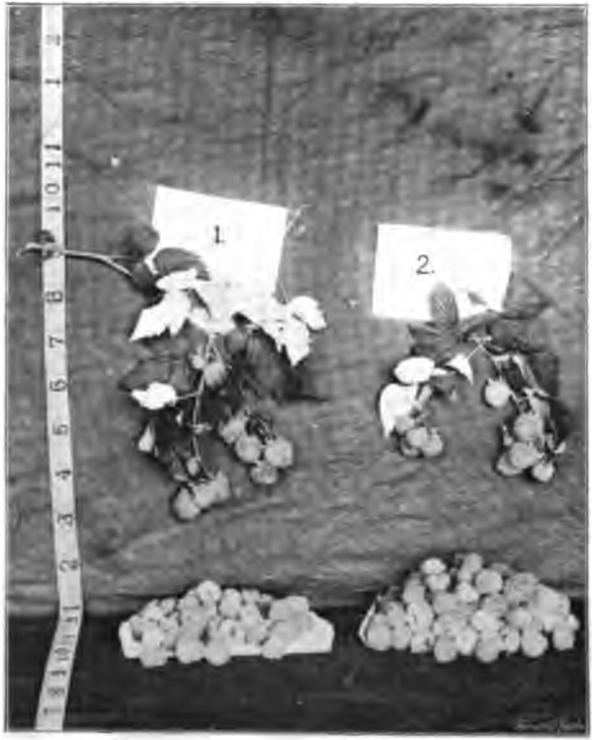


DOWNING GOOSEBERRY. Lander, 1895.



RASPBERRIES. 1, Caroline. 2, Golden Queen. Lander, 1895.

value. There is a good demand for raspberries in the Lander market. Those marketed in 1894 sold for 33 1-3 cents per quart.

Raspberries, 1894.

Variety.	No. planted	Obtained from.	No. died.	Date ripe, 1804.	Remarks.
RED—					
Turner	25	Lovett	....	July 8	Prolific
Early Prolific	15	“	....	June 30	Early
Hansel	25	Henderson	....	July 12	One of best.
Brandywine	27	“	....	July 12	Good.
Everbearing	14	Shields	All	.....	
Cuthbert	23	“	All	.....	
YELLOW—					
Golden Queen	26	Lovett	....	Aug. 2	Large. Good.
Caroline	15	Henderson	....	.....	
Brinkle's Orange	10	“	All	.....	
BLACK—					
The Lovett	12	Lovett	....	July 8	Good.
Ada	24	“	8	July 27	Only a few.
Gregg	24	“	....	July 27	One of best.
Kansas	12	“	....	July 12	One of best.
Ohio	12	Spear	All	.....	
Mammoth Cluster	24	“	All	.....	
Progress	14	Henderson	All	.....	
Everbearing	12	Shields	All	.....	
Miller's Daily	......	“	All	.....	
Souhegan	24	“	All	.....	
Congress	14	....	....	July 8	Productive.

Raspberries, 1895.

Variety.	In bloom.	First ripe.	Last picked.	Yield per acre in quarts.
RED—				
Brandywine	June 22	July 20	Aug. 21	1605
Marlboro	“ 12	“ 8	“ 17	1746
Early Prolific	“ “	“ 6	“ “	3289
Hansel	“ “	“ 8	“ 21	2259
Turner	“ 15	“ 13	“ 17	3160
BLACK—				
Ada	“ 22	“ 25	“ 21	1815
Gregg	“ “	“ 24	“ “	876
Progress	“ 15	“ 15	“ “	2674
Kansas	“ “	“ 18	“ 17	2425
Lovett	“ “	“ 20	“ 7	1705
YELLOW—				
Golden Queen	“ 12	“ 7	Sept. 7*	3131
Caroline	“ 15	“ 10	“ “*	1149

*Frosted Sept. 7th. There was still some green fruit on bushes at this time.

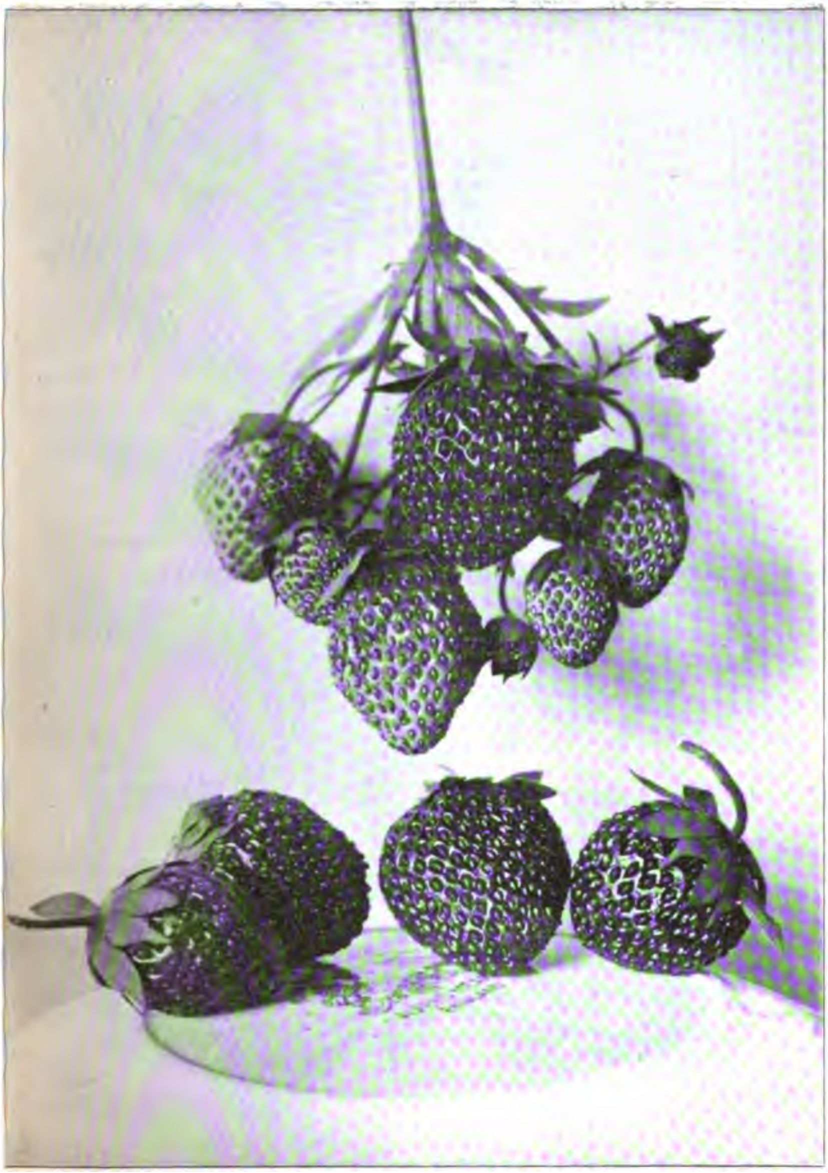
Japanese Wineberry.

Our experience with this berry does not indicate that it will be profitable to grow for market. The plants did not come into bearing until the third season after setting them out and then only under favorable conditions. The first fruit was produced in 1895. The blossoms withstood heavy late frosts in the spring as well as those of the blackberries or other raspberries. The yield was at the rate of 984 quarts per acre.

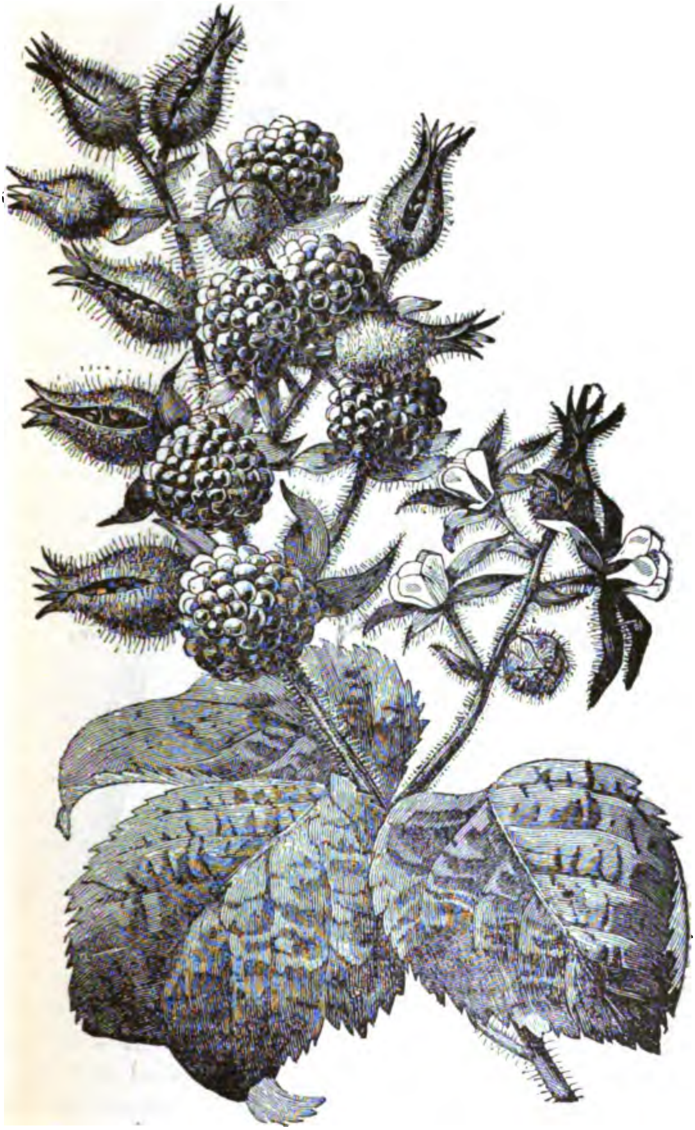
As we stated in "American Gardening" of April 18, 1896, the delicate, juicy, sub-acid berries are most delicious. The calyx of the flower protects them from dust and insects until the time of ripening, when the calyx leaves open and disclose a morsel tempting to the eye and palate. This is very well shown in the illustration of a fruiting branch which we have obtained through the courtesy of the publishers of "American Gardening." We also show a picture of a box of the fruit which was made from one of our own photographs and published in "American Gardening." A few bushes for home use should be planted in a sheltered corner of every garden. They will repay a great amount of care and patience; and the sensation produced by seeing and eating the first berries to ripen will be a pleasant experience to all lovers of the rare and beautiful. The berries are too soft to ship well, but could be produced for local market. The yield produced in 1895 would sell for nearly $300 per acre.

Strawberries.

Thirty-five varieties were planted in May, 1892. Twelve varieties obtained from Peter Henderson were pot grown plants. These were so tender that only a few of each lived the first year. The bed was kept clean in the summer of 1892 by frequent hoeing. In the fall the native fox-tail was allowed to grow up in the bed. This was frosted before the seed ripened and made a very good protection for the strawberries during the winter. Those varieties which did not fruit in 1893 were Prince of Berries, Perry, Jucunda Improved, Edgar Queen, Stevens, Florence, Lovett's Early, Jennings' White, Nectar, and Iowa Beauty.



EDGAR QUEEN STRAWBERRY, Natural Size. Lander, 1897.



FRUITING BRANCH OF JAPANESE WINEBERRY.

(*By courtesy of "American Gardening."*)

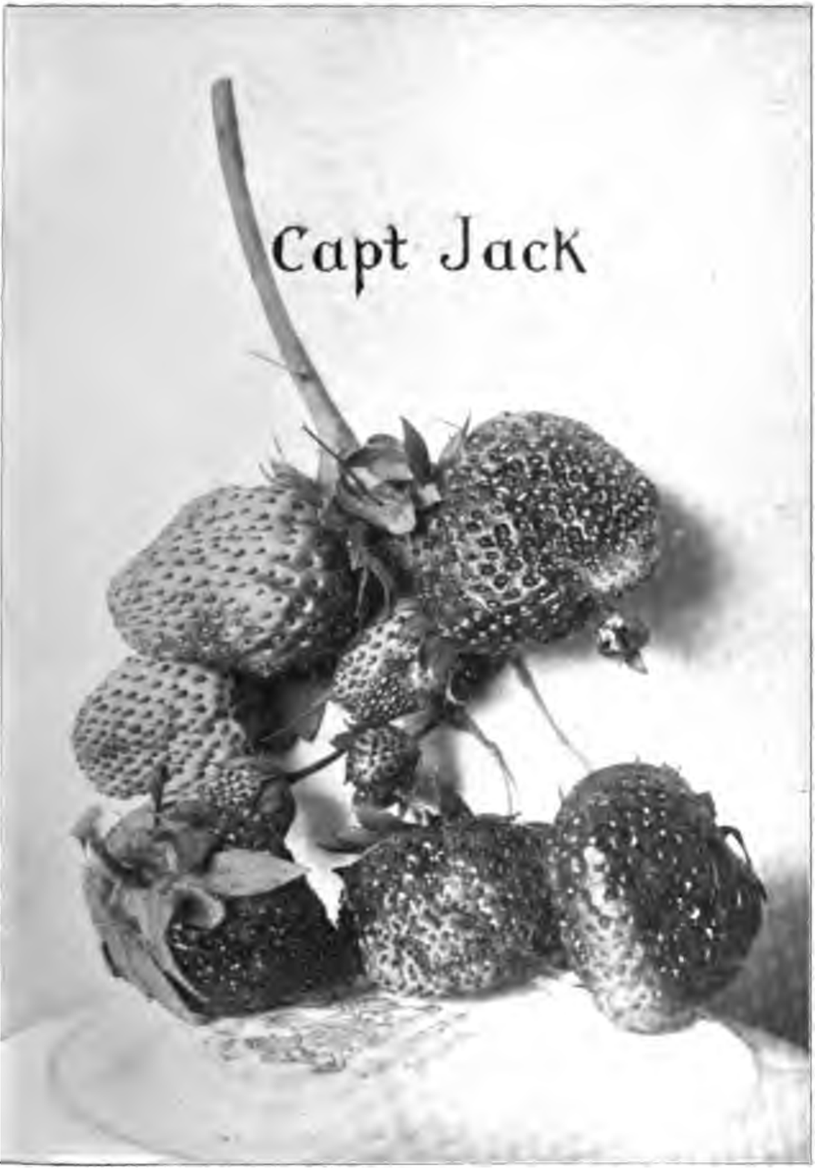
The varieties that fruited but did not produce heavy crops, were Jessie, Charles Downing, Beebe, Ganda, Mitchel's, and Belmont.

The varieties which produced heavy crops in 1893 were Warfield, Bubach, Mammoth, Sharpless, Gold, Cloud, Parker Earl, Shuster's Gem, Wilson, Lady Rusk, Captain Jack, Viola, Bidwell, Triumph, Crescent Seedling, Manchester, Cumberland, and Staymen's No. 1.

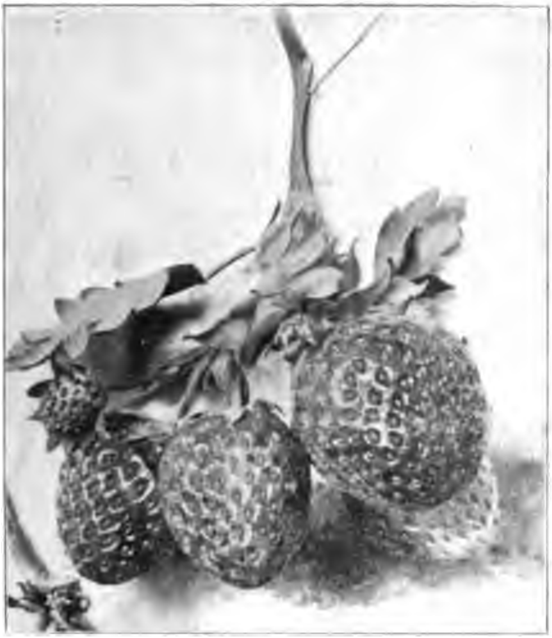
In the winter of 1893 the strawberries were given a light mulch of stable manure. No report upon them is at hand for 1894, as the crickets destroyed nearly everything that season. In the spring of 1895 the blooming and setting of fruit gave promise of a large yield of berries, but the late heavy frosts killed the blossoms and dwarfed the berries which were formed. But few berries matured, and those which did ripen were small and woody. This was true of all varieties. The same strawberry bed was kept over and gave a good crop of berries the past season.

The record for 1897 is given in the table. The yields obtained and the size and quality of the berries show that a strawberry bed may be kept longer than two or three fruiting seasons. However, the accidents that prevented heavy crops of berries in 1894 and 1895 may have left the plants in better condition for a full crop as late as 1897. The table gives the earliness, season, size, shape, flavor, shipping qualities, and productiveness of the varieties that have succeeded best.

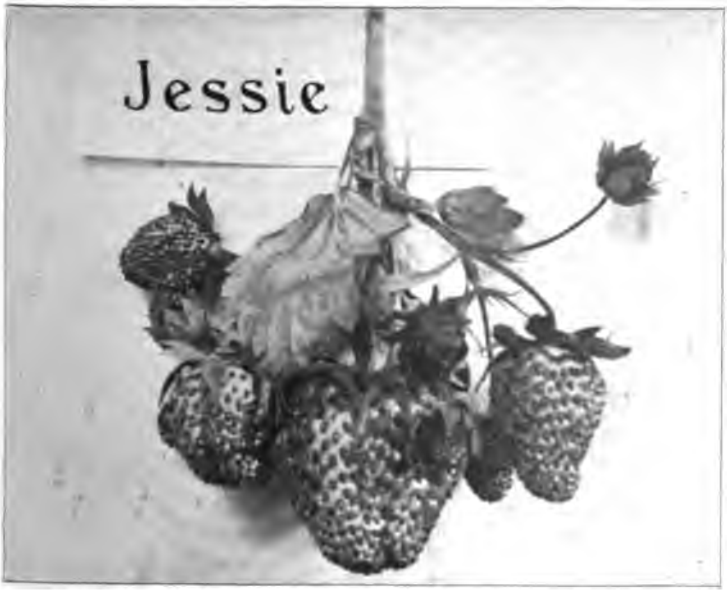
Not enough strawberries are raised to supply the Lander market. This season many crates from other states were shipped to Lander, being carried over 130 miles by stage. They are of such easy culture and succeed so well that no one should send money out of Fremont county for them, nor should they be satisfied with stale, dusty berries shipped from such distances.



CAPT. JACK STRAWBERRY, Natural Size. Lander, 1897.



BIDWELL STRAWBERRY, Natural Size. Lander, 1897.



JESSIE STRAWBERRY, Natural Size. Lander, 1897.

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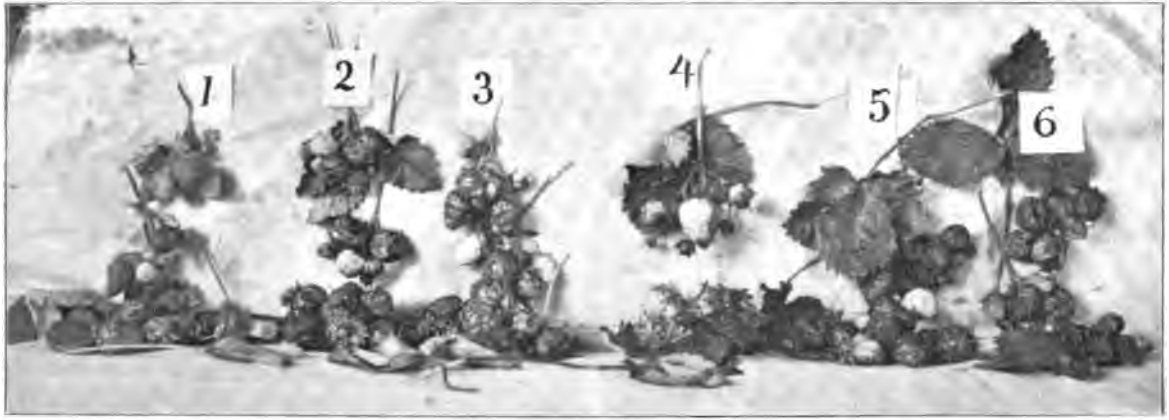


STRAWBERRIES. Lander, 1897. (One-fifth natural size.)

1, Bidwell 2, Crescent. 3, Parker Earl. 4, Charles Downing. 5, Cloud. 6, Stamen's No. 1.

Strawberries, 1897.

Variety.	Date of first bloom.	Date first were ripe.	Date last were picked.	Weight of largest twelve.	Diam. of largest berries.	Flavor.	Shape.	Shipping qualities.	Yield per acre
				ounces.	*inches.*				*quarts.*
Mitchel's Early.	May 8	June 12	June 22	. . . .	Small	Very sweet	Flat	Good	2784
Crescent.	" 8	" 12	July 9	3	1 1-16	Sweet	Bell	Fair	5699
Chas. Downing.	" 12	" 15	" 9	3	1⅛	Tart	"	Good	2848
Jessie	" 12	" 14	" 9	3	1⅛	"	"	"	4361
Bubach	" 15	" 16	" 9	2½	1	"	Long, round, blunt	"	4154
Lovett's Early	" 8	" 12	" 9	2½	1	"	Long, round, pointed	Fair	4416
Stephens.	" 15	" 15	" 4	2	¾	"	Pointed	Medium	2178
Capt. Jack.	" 15	" 15	" 6	2½	1	"	Bell	Good	5555
Jucunda	" 12	" 15	" 9	3	1⅛	Sweet	Round, pointed	Poor	2976
Sharpless.	" 12	" 14	" 9	3	1⅛	Sour	Wedge	Good	4640
Crimson Cluster.	" 12	" 15	" 9	2	⅞	Tart	Short, round, pointed	"	4750
Bidwell.	" 15	" 15	" 6	2	¾	"	Wedge	"	3735
Cloud	" 15	" 16	June 28	1½	¾	"	Pointed	Medium	*
Parker Earl	" 12	" 14	July 4	2	¾	Medium acid	Round, small, pointed	Poor	3568
Edgar Queen	" 12	" 15	" 9	2½	1	Sweet	Round	Good	4530
Perry.	" 15	" 16	" 6	1½	⅞	Tart	Round, stubby	Poor	870

*A few nice berries, but no record kept.

FRUIT GROWERS IN FREMONT COUNTY AND THEIR SUCCESS.

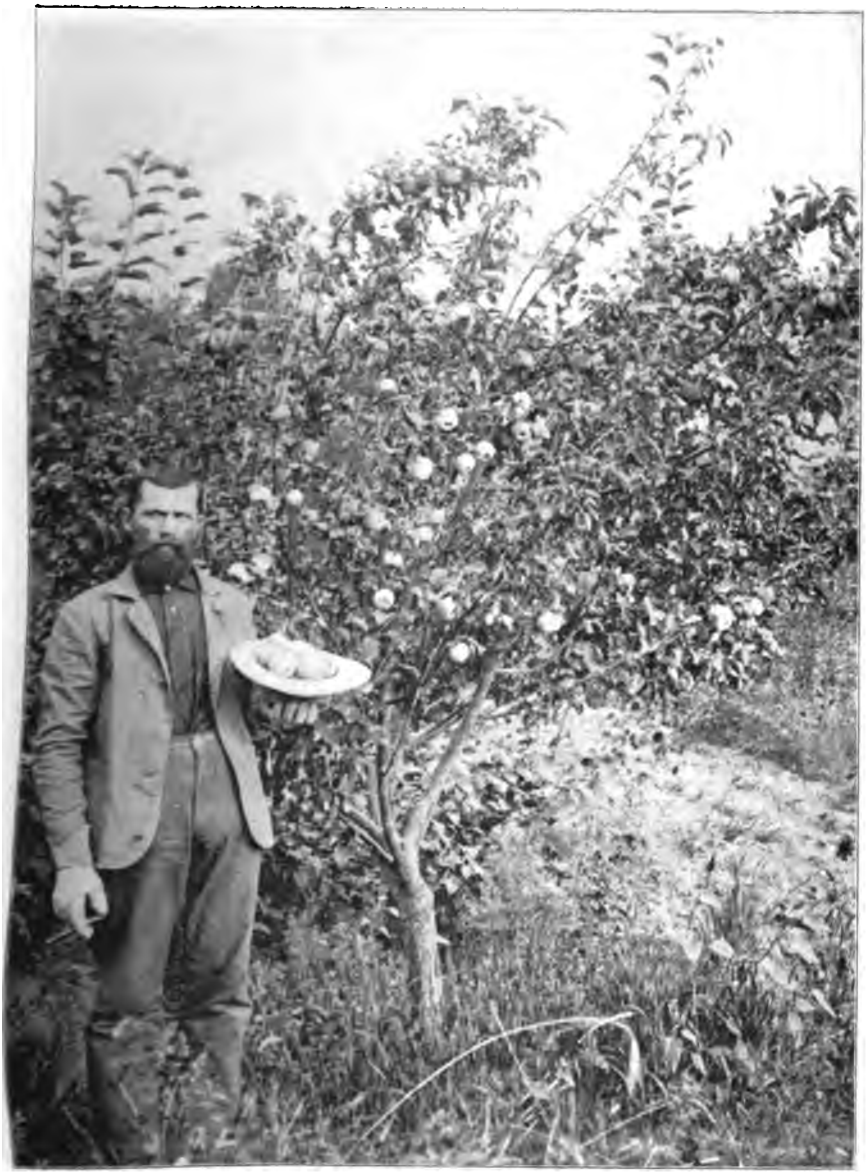
Those farmers who have succeeded in fruit raising in the vicinity of Lander so far as we can learn are Mr. R. H. Hall, Mr. J. B. Houghton, Mr. J. S. Meyer, Mr. Nickerson, Mr. F. Nichol, Mr. E. Tweed, and Mr. Ed. Young. We understand that Mr. Hall has been raising small fruits a number of years and has some fruit trees planted. Mr. J. S. Meyer has raised quantities of small fruits and planted quite an extensive orchard which has been bearing for a number of years. We call attention to the illustrations of trees in his orchard, made from photographs taken in 1895. The Duchess apple tree shown has produced heavy crops of very large, perfect fruit for a number of years. Mr. Meyer gives a brief account of his experiments with fruits in the following letter, written September 9, 1897.

Letter from Mr. J. S. Meyer.

"I find from experience that fruit can be grown in the Lander valley at an altitude of 5300 feet, and while we have some difficulties to overcome, the more experience we have, the more successful we will be in getting our orchards to bearing.

"I fully expected that by this time we should be able to determine from trees set out on the Lander Experiment Farm and my own farm such varieties as would be a success here, but unfortunately, September 20, 1895, the thermometer dropped to within 12 degrees of zero, while our trees were in full leaf and the sap up, which resulted in killing all trees that were planted as late as 1893. In my home orchard I lost 50 per cent of trees planted in 1892 and 75 per cent of those set out a year later. My older trees that were planted prior to 1892 were damaged but little, which goes to prove that had we begun planting trees earlier we would today be growing apples in abundance.

I have eight trees that were set out in 1885 which have



OLDENBURG APPLE.

Orchard of J. S. Meyer, Lander, 1895.

not missed bearing the last six or seven years. In no country could they have done better than here; in fact, the trees are always too full of fruit.

The varieties consist of Duchess of Oldenburg,* Wealthy, Briar Sweet,† Soulard Crab, and the Siberian Crab. I have this year apples growing on trees that were planted in 1892 and 1893 of the following varieties that withstood the September freeze of 1895, and are very promising: Wealthy. Duchess. Yellow Transparent, Whitney, Soulard Crab, Martha Crab, Montreal Beauty Crab, the last being the hardiest and most prolific of the crab varieties.

"The following trees put out in the spring of 1893 withstood the freeze of September, 1895, with losses as follows: Wealthy, 15 per cent; Duchess, 30 per cent; Ben Davis, 20 per cent; Yellow Transparent, 30 per cent; Martha Crab, 25 per cent; Soulard and Montreal Crab, 15 per cent. With the small loss of the above varieties we have four standard varieties and three crabs that have been tested and found all right for this climate and altitude, and which I would not hesitate to recommend for planting by anyone who will give them reasonable care.

"I have grown very successfully for a number of years quite a variety of small fruits, viz.: Blackberries, raspberries, gooseberries, currants, strawberries, and grapes. The success with grapes this year on the Lander Experiment Farm is enough to convince anyone that all that is necessary to grow our own grapes is to set them out and give them the attention they need. The following varieties are loaded with fruit: Concord, Wyoming Red, and Delaware. They are grown without difficulty, as they are so easily protected in the winter. Blackberries and raspberries have to be covered with dirt. Strawberries need very little winter protection.

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*Called Oldenburg in other parts of this bulletin.

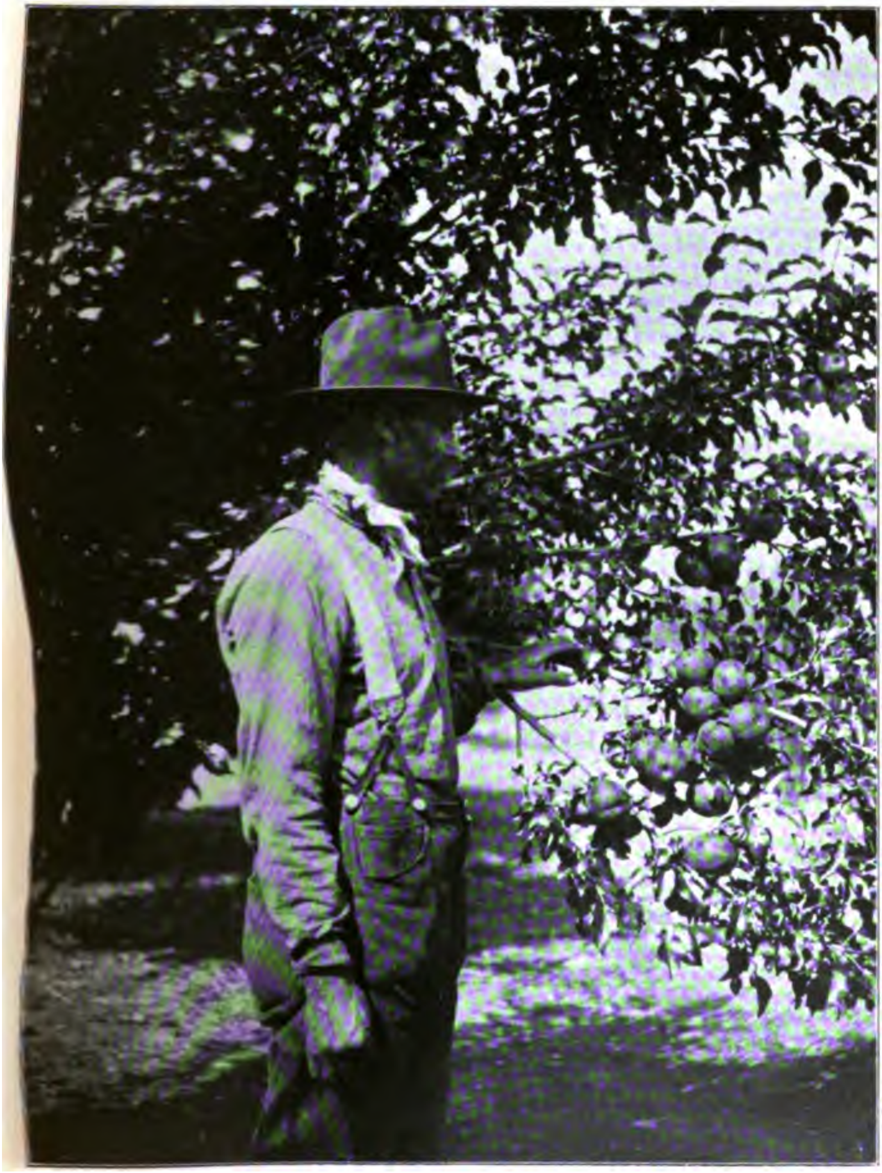
†Also known as Van Wyck.

"In conclusion, I wish to say that it is a matter of only a few years until the Lander valley is growing its own fruit. Only a few days ago I met a neighbor, Mr. Ed. Young, on the streets of Lander with a load of apples of his own growing.

"It has been only a few years since I hauled apples from Holt county, Missouri, to Lincoln, Nebraska, and at that time the people of Nebraska thought they could not grow fruit. Look at the fruit produced there today! Wyoming can do even better, as we have the advantage of irrigation."

Mr. Nickerson, whose farm adjoins the experiment farm on the west, has raised several varieties of apples with success, and now is making a business of raising small fruits. Mr. Ed. Young, whose farm is situated at the mouth of the Little Popo Agie canon, above Dallas, has been very successful with apples. In the fall of 1891 he wrote us that his trees had been overloaded for two years and had not winter killed. We visited his farm in the fall of 1895 and secured some photographs of his trees, one of which is reproduced in this report. In 1894 he had about one hundred trees in bearing of the Oldenburg, Wealthy, Whitney Crab, Great Lakes Siberian Crab, Sweet Russet, and Transparent varieties, marketing that year about 5,000 pounds of apples. The same year he had some De Soto and Rolling Stone plum trees in bearing.

At the time of our visit, Mr. Young had between two thousand and three thousand apple trees, three, four, and five years old, on his place, there being over one thousand Wealthy and large numbers of the following varieties: Tetofsky, McMahon, Wolf River, Hybernal, Oldenburg, Transparent, Sweet Russet, Longfield, Windsor Chief, and Lowland Raspberry. There were also some fine trees of Gakovska and Bessemianka pears, and Early Richmond cherries and Russian apricots. We learn that Mr. Young marketed large quantities of apples in 1896 and 1897.



WEALTHY APPLES.

Orchard of Ed. Young. Dallas, Fremont County, 1895.

SHERIDAN.

The agricultural lands of Sheridan county consist mainly of the valleys along the streams and the adjoining uplands that can be irrigated by ditches taken from these streams. The altitude is lower than that of most parts of the state, much of the land being less than 4,000 feet above sea level. The soil differs from that of the other parts of the state. It is alluvial deposit or clay soil rich in the inorganic plant foods. In places where the drainage is poor the soil contains a large amount of alkali.* The water used for irrigation is very pure when it comes from the Big Horn mountains, but in its course across the lower lands it takes up considerable quantities of salts from the soil. That used upon the experiment farm carries considerable alkali.† The character of the soil and water makes drainage of any land to be used for the production of fruits an important consideration. The fertility of the soil, the low altitude, and comparatively long summer season, the rolling character of the land and the nearness of the Big Horn mountains cause conditions which make fruit raising about Sheridan successful.

Fruits Upon the Experiment Farm.

The experiment farm was established in 1891 and in the spring of 1892 a total of more than one hundred sixty-five varieties of fruits were planted. At that time the trees and plants had to be shipped a long distance by wagon, and much of the stock was en route so long that it arrived in poor condition and did not grow after being planted. However, a few of nearly all varieties were saved, so we are able to report most of them. The fruit plats have a gentle slope toward the west and north.

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*See Bulletin No. 6, "Soils of the Agricultural Experiment Farms," page 19, and Bulletin No. 14, "Geology of the Wyoming Experiment Farms," page 112.

†See Bulletin No. 24, "Water Analyses," page 117.

THE ORCHARD.

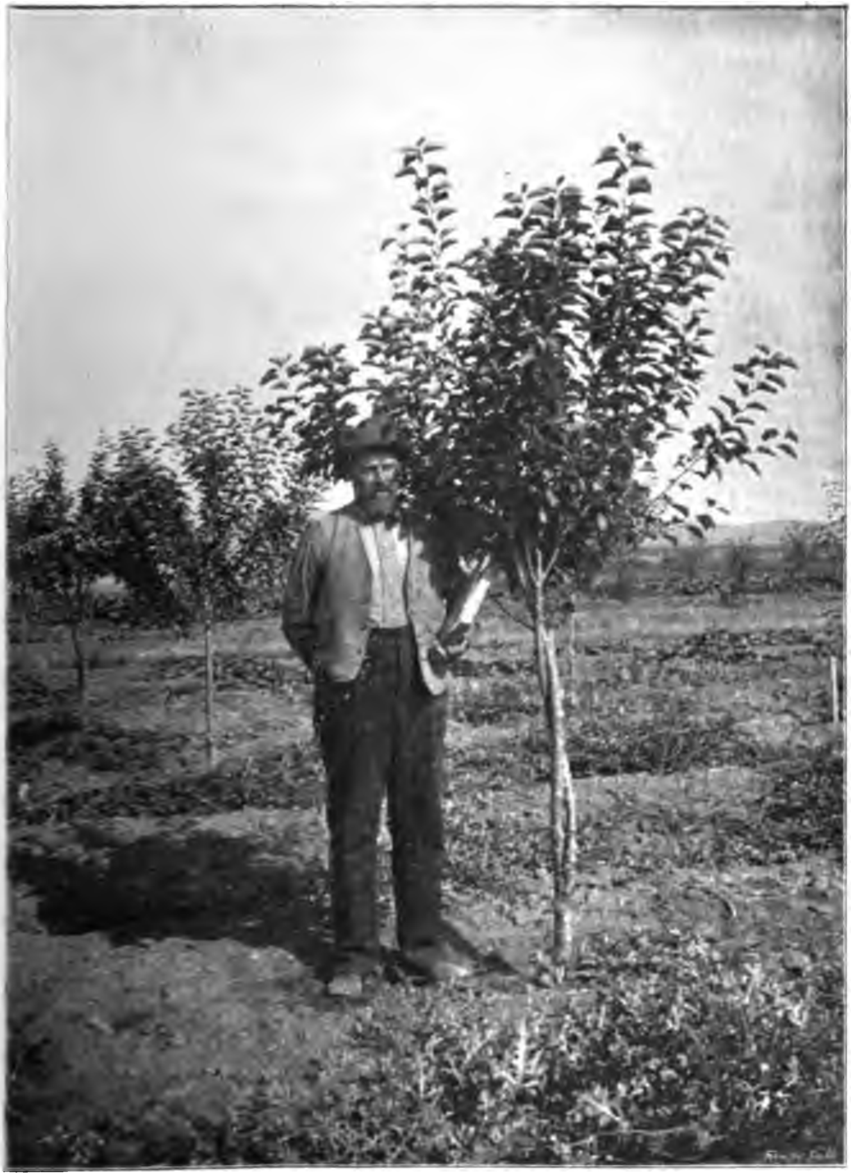
The trees in the orchard which lived after being set out and through the first year, made good growth and were in excellent condition in the fall of 1895. In the latter part of August of that year several rains occurred, which caused the sap to increase in the trees, and the sudden storm and freeze of September 20th killed nearly all the young trees. The storm had the same effect as was produced at Lander, older orchards in the county not being injured to so great an extent. Some of the trees were so injured by rabbits during the first two years that they died from the effects.

Apples.

Following is a list, giving the number of each variety planted in the spring of 1892: Four Whitney Crab; four General Grant, four Transcendent Crab, four Martha Crab, ten Hyslop Crab, twelve Oldenburg, twelve Wealthy, twelve Tetofsky, twelve Ben Davis, and six each of Red Astrachan, McMahon, Wolf River, Yellow Transparent, Willow Twig, Early Harvest, St. Lawrence, Wine Sap, Pennock, Lawver, Red Transparent, and Bailey's Sweet.

On account of the condition of the stock when received, the number of each left alive does not indicate hardiness, and is omitted. As the trees died their spaces were filled in by plantings of other varieties, but we have no reports showing just what has been done.

In 1895 the orchard presented a good appearance. The trees were thrifty. General Grant, of which we show a picture of the row of trees, was in bearing. Martha Crab also produced some fruit, and one Ben Davis tree produced a



GEN. GRANT CRAB TREES. Sheridan, 1895.

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single apple. A number of trees of each of the following varieties were set out in 1895, having been obtained from G. W. Barlow of Sheridan: Northwest Greening, Yellow Transparent, Pewaukee, Wealthy, Haas, Huntman's Favorite, McIntosh Red. The trees which were killed in the fall of 1895 were all removed the following spring and none have been replaced on the farm since that time.

Cherries.

The following varieties were planted in 1892: Six Ostheim, three Little Phil, six English Morello, three Sport Amorilla (?), six Early Richmond. None of these have been hardy enough to withstand the winters and bear fruit. The roots live, but the tops die down to the ground each year.

Pears.

The pears were not hardy, nearly all of them dying to the ground each winter. Flemish Beauty was the only variety which had made a well formed tree in 1895.

Plums.

Forest Garden, Weaver, Quaker, Wolf, Hawkeye, De Soto, Abundance, Mooney, Blood Golden, Yellow Egg, Green Gage, Toronto, Lombard, and Marianna have been tried. The Marianna, Lombard, Green Gage, and Mooney blossomed and set fruit in 1895, but the late frosts caused them to fall off, so none were matured. Our illustration shows the Mooney plum tree at that time. These varieties seem to be hardy and should be given further trial.

GRAPES.

No grapes have been reported as maturing fruit, though in 1895 good bunches of grapes were formed on Green Mountain and Brighton. The vines were injured by the frost of May 28, 1895. The varieties which have been most hardy are Green Mountain, Brighton, Concord, Delaware, and Martha, in the order named.

SMALL FRUITS.

Blackberries and Dewberries.

The blackberries set out in 1892 were Early Harvest, Wilson Jr., Wilson's Early, Early King, Erie, Lawton, Child's Tree, Lovett's Best, and Early Cluster. Alll the plants of the last four varieties named died the first winter. The following varieties have borne fruit in 1895 and 1896:

SNYDER.—In 1895, this variety came in bloom June 20. The berries were ripe August 10, but the canes were not prolific. In 1896, the canes came into bloom June 15. The berries were ripe August 10. Most of the fruit was eaten by birds and no yields were noted.

WILSON JR.—In 1895, the canes were in bloom June 2. The berries were ripe August 10, but the canes were not prolific. The berries were large and the canes thrifty. The canes are very thorny, and while they have a trailing habit they are not more easily handled and covered for the winter than other varieties. In 1896, the canes came into bloom June 15, and the berries were ripe August 10.

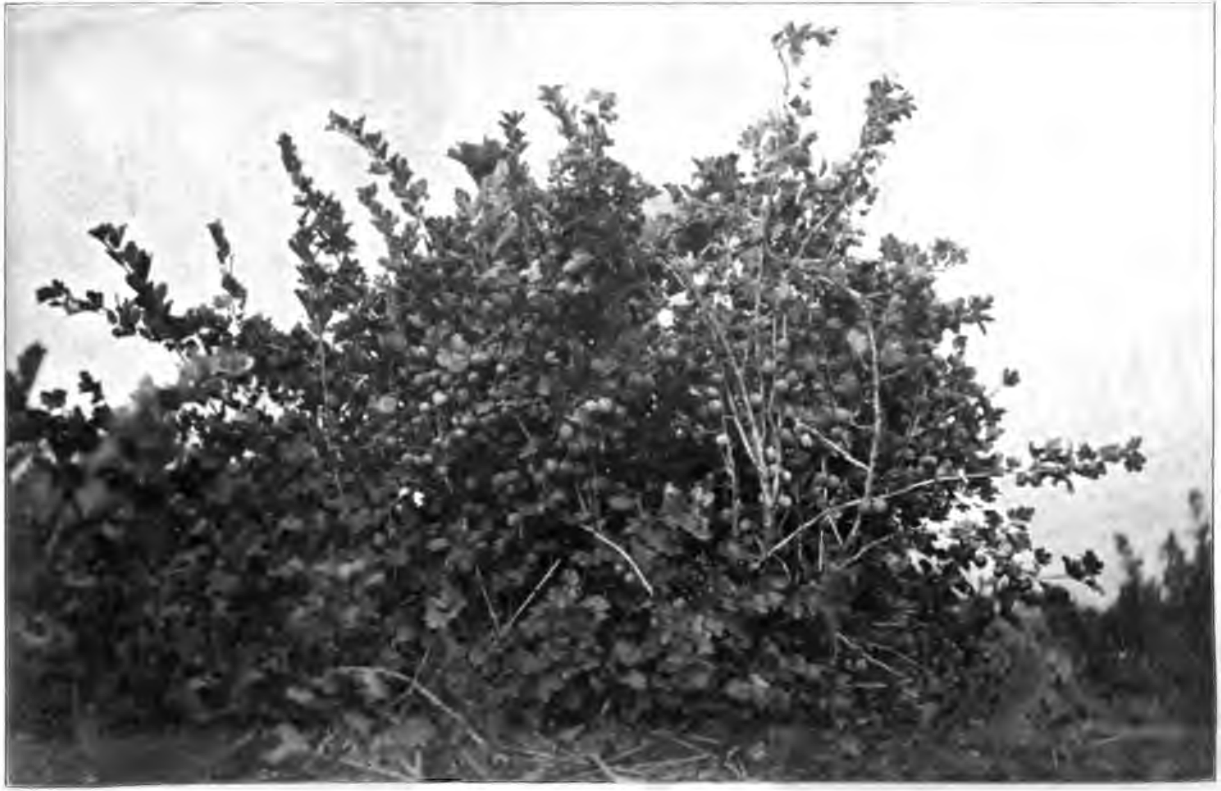
EARLY KING.—This is the best variety tried. In 1895 it came into bloom June 1, and the berries were ripe August 5. The canes are hardy and prolific bearers, the berries large and of excellent quality. In 1896, this variety was in bloom June 15, and the berries were ripe August 10.

MAMMOTH DEWBERRIES.—This variety was only reported in 1895. They bloomed June 2 and were ripe August 1. This was the most prolific dewberry in 1895, yielding at the rate of about 2,000 quarts per acre.

LUCRETIA DEWBERRY.—The canes were in bloom June 2 and the berries were ripe August 1 of 1895, when they bore a heavy crop.

Currants.

All the varieties are hardy except Ruby, which has not succeeded well. The best varieties are Red Cherry and



INDUSTRY GOOSEBERRY Sheridan, 1893.

White Grape. Lee's Prolific has borne well, but we think Crandall the best black variety.

Currants, 1895.

Variety.	Date of bloom.	Date first ripe.	Yield per acre, gallons.
Red Cherry	May 1	July 25	3120
Fay's Red	" 12	" 20	.....
Ruby	" 12	" 20	.....
Crandall	" 10	" 20	3360
Lee's Prolific	" 7	" 28	2290
White Grape	" 5	" 25	3120

Currants, 1896.

Variety.	Date of bloom.	Date first ripe.	Dates of pickings.	Yield per acre, gallons.
Red Cherry	May 12	July 1	July 2 to 20	1900
Fay's Red	" 12	" 7	" 7 to 20	570
Ruby	" 10	" 1	" 1 to 20	.....
Crandall	" 8	" 20	" 20 to 30	1995
Lee's Prolific	" 10	" 6	" 15 to 20	1567
White Grape	" 14	" 6	" 7 to 20	544

Gooseberries.

Industry and Downing produced fruit in 1894, ripening from July 1st to 12th. The Downing was more prolific and better in every way than the Industry. The following tables give the results in 1895 and 1896. Our illustration shows the character of the Industry gooseberry, the limbs being raised to show the fruit. Golden Prolific has little merit. We recommend Downing for general planting.

Gooseberries, 1895.

Variety.	Date of bloom.	Date first ripe.	Yield per acre, gallons.
Industry	May 1	July 20	600
Downing	" 2	" 10	1800
Houghton	" 7	" 20	1500
Golden Prolific	" 4	.....	.....

Gooseberries, 1896.

Variety.	Date of bloom.	Date first ripe.	Dates of pickings.	Yield per acre, gallons.
Industry	May 10	Aug. 1	Aug. 1 to 30	2775
Downing	" 13	July 20	July 20 to Aug. 30	3800
Houghton	" 14	Aug. 5	Aug. 5 to 25	2385
Golden Prolific	" 14	" 10	....	.....

Raspberries.

As the raspberries have succeeded so well it is regretted that the varieties were so mixed when set out that the work with them cannot be reported as an accurate variety test. Since they began to bear fruit, however, the varieties have been located and reported upon in such a way that at least a part of them are comparable, and the yields and other notes given in the table for the season of 1895 indicate which have proven of greatest value. In 1894, the red varieties which produced the most fruit were Hansel, Brandywine, Cuthbert, and Turner. Of these, the Brandywine, Cuthbert, and Turner were the most prolific and best.

Of the yellow sorts, Caroline and Golden Queen were prolific, the first being of excellent quality.

The black varieties which produced the largest crops were Kansas and Progress, the Kansas being the most prolific.

In 1895, the raspberries produced excellent crops. In the following table we include only those varieties which were not badly mixed in the rows, and their comparative earliness and productiveness is indicated. The Shaffer is a purple berry rather than black.

Variety.	Date in bloom.	Date ripe.	Yield per acre, quarts.
RED—			
Hansel	May 29	July 20	1080
Brandywine	" 29	" 20	1680
Early Prolific	June 12	" 25	1440
Marlboro	" 16	" 20	....
YELLOW—			
Golden Queen	" 1	" 20	960
Brinkle's Orange	" 15	" 30	1080
Caroline	" 15	" 30	720
BLACKCAPS—			
Gregg	" 2	" 25	780
Shaffer	" 1	" 30	600
Lovett's Black	" 5	" 30	1220
Kansas	" 5	" 30	720

The superintendent reported that 50 per cent of the red varieties and 80 per cent of the black caps were killed by

TURNER AND MAMMOTH CLUSTER RASPBERRIES Sheridan, 1896.

(*Photo by Trone.*)

the storm of September 20, 1895. The yields were comparatively small in 1896. The varieties being mixed, we cannot report all of them, as the results cannot be depended upon where the varieties reported are not true to name. The following three red varieties are the only ones upon which the data is sufficiently accurate.

HANSEL.—The canes were in bloom June 15 and the first berries were ripe July 10. They were harvested from July 15 to 28, and yielded at the rate of 886 quarts per acre.

BRANDYWINE.—This variety came into bloom June 17. The first berries were ripe July 13. They were harvested from July 15 to 28, and yielded at the rate of 555 quarts per acre.

CUTHBERT.—The canes were in bloom June 18. The first berries were ripe July 10. They were harvested from July 15 to 26, and yielded at the rate of 887 quarts per acre.

Other varieties which produced good crops were Lovett's Best, Kansas, Brinkle's Orange, and Marlboro. Marlboro is reported as mixed with Japanese Wineberry, but as the latter has never borne fruit at Sheridan we report the yield given for Marlboro. While not quite so early as Hansel, Brandywine, or Cuthbert, the Marlboro produced the heaviest crop of any berry reported in 1896, the yield being 1425 quarts per acre. We show illustration of two varieties of raspberries at time of harvest in 1896.

Cost and Profit.

The yields computed by Superintendent Lewis for the two seasons, 1895 and 1896, give an average from all varieties grown of 953 quarts per acre. The market price was 25 cents per quart, giving an average value of $238.25. Mr. Lewis estimated the cost of picking at two cents per quart, but we think this too low. We believe five cents per quart would be a fair estimate of the expense of boxes, and picking and crating the berries. Mr. Lewis estimates the cost of raising an acre of raspberries at $18. This, with the total expense of picking and marketing the berries would make the cost per acre $65.65. It must be remembered that the estimate of yield given is an average of a large number of varieties, among which are many kinds which are very poor yielders, and any one raising a few of the better kinds would obtain much greater yields.

However, this low average gives the following profit:

Average yield per acre of all varieties for two years 963 quarts—value in local market	$238.25
Total cost, including picking and marketing the crop	65.65
Net profit per acre	$172.60

STRAWBERRIES.

Sixty-two varieties of strawberries were set out, but not all of them succeeded, as the pot-grown plants were too tender, and all died after being transplanted. The plants were set so far apart that they did not form matted rows until after the crop of 1894. They were planted eighteen inches apart in rows five feet apart. The table for 1894 gives the record as furnished by the superintendent.

In 1895 all the varieties bore a few berries but the frosts of May 15, 16 and 28 killed the larger part of the blossoms. Otherwise there would have been a heavy crop. No weeds were allowed to grow in the bed and the most of the varieties produced thickly matted rows, some of them being five feet in width. The earliest varieties to ripen were Lovett's Early and Warfield, and those which were most prolific and of best quality were Gandy, Warfield, Jucunda Improved, Lovett's Early, Iowa Beauty, Eureka, Mitchel's Early, Cresent, Haverland, Jessie, Cumberland, and Manchester. In 1893 the Eureka produced large fruit, a single berry measuring seven inches in circumference and weighing two ounces. In 1894 the Eureka and Gandy produced large berries, six berries of each being found which meas-

NEW STRAWBERRY BED. Sheridan, 1896.
(*Photo by Trone.*)

ured six and one-fourth inches in circumference. In 1896 the old strawberry bed gave larger yields from the different varieties and the data is given in the table for that year. A new bed was planted in 1896 of which an illustration is given.

Strawberries, Sheridan, 1894.

Variety.	Date of first bloom.	Date first ripe.	Yield from 6 hills. quarts.	Remarks
Jessie		July 1	3.5	
Hart's Minnesota		" 2	....	
Mitchel's Early		June 25	4	
Miner's Prolific		.....	....	
Crescent		" 27	5	
Old Ironclad		July 29	2.5	
Manchester		" 4	2.5	
Great Pacific		.....	....	
Lady Rusk		June 30	4.5	
Bidwell	June 10	....	....	Tender; winter kills.
Cumberland	" 8	July 7	3.5	Large, smooth, solid.
Crawford	" 10	" 6	....	Not good
Sharpless	" 12	.....	....	Not hardy.
Capt. Jack	" 12	" 9	4.5	Hardy; prolific.
Bubach No. 5	" 15	" 12	....	Tender; poor.
Gandy	" 9	" 7	4	Vines tender; fruit fine.
Eureka	" 9	" 1	4	Fruit large; rough.
Haverland	May 30	June 28	....	Poor.
Monmouth	.....	.....	....	Tender.
Wilson	June 7	July 1	4	Prolific.
Warfield	" 1	June 25	5	Hardy and prolific.
Stayman's No. 1	" 7	July 3	2.5	Fruit soft; thrifty.
Stevens	.....	.....	....	Winter kills.
Shuster's Gem	" 20	" 10	2.5	Fruit fine; plants tender.
Iowa Beauty	" 12	" 10	2.5	Fruit small; plants hardy.
Viola	.....	.....	....	Winter killed.
Florence	.....	.....	....	Winter killed.
Jucunda Improved	" 4	" 2	3	Fruit fine; plants hardy.
Yale	.....	.....	....	Not good.
Standard	.....	.....	....	Winter killed.

Cost and Profit.

An estimate of the cost and profit from an acre of strawberries at Sheridan for 1896 may be of interest. The thirty-one varieties which gave yields large enough to be recorded produced an average of 6,920 quarts per acre. The prices ranged from 10 to 15 cents per quart. Taking the lowest price, all varieties, good, bad, and indifferent, would have an average value of $692 per acre. The superintendent's estimate of the cost of raising an acre of strawberries is $93. We think this would set out a new acre to the very best plants every year, allowing $4 per thousand for the plants.

Three cents per quart would be a liberal estimate of the cost of picking, boxing, crating, and hauling to market, or a total of $208.60 per acre. These figures would give the lowest probable profit. A few of the better varieties would give much better yields, and we have allowed a liberal amount for expense.

Average value per acre of crop from thirty-one varieties at 10 cents per quart	$692.00
Total cost, including picking, setting out new beds each year, etc	301.60
Net profit per acre	$390.40

Strawberries, Sheridan, 1896.

No.	Variety.	Date in bloom.	Date frosted.	Character of plant.	Date first ripe.	Date last ripe.	Shipping qualities.	Yield per acre, qts.
1	Hart's Minnesota	May 22	May 20	Large	June 20	July 13	Good	7480
2	Jessie	" 29	" 20	"	" 23	" 13	"	3740
3	Mitchel's Early	" 20	" 20	Thrifty	" 20	.....	....	None
4	Miner's Prolific	" 25	None	Small	" 28	" 13	"	3740
5	Crescent	" 26	"	Large	" 20	" 13	"	6035
6	Old Ironclad	" 24	"	"	" 22	" 13	....	6455
7	Manchester	" 28	"	"	" 28	" 16	"	5610
8	Lady Rusk	" 19	May 20	"	None	.....	....	None
9	Bidwell	" 19	" 20	Very tender	"	.....	....	"
10	Cumberland	" 25	None	Large	June 20	" 13	"	7480
11	Crawford's No 1	None	"	Small; poor	None	.....	....	None
12	Sharpless	May 26	"	Large	June 25	" 13	....	7905
13	Capt. Jack	" 26	"	Short, stocky	" 24	" 13	"	9350
14	Bubach	" 30	"	Large	" 24	" 12	"	6035
15	Gandy	" 27	"	"	" 23	" 14	....	9350
16	Eureka	" 23	"	Weak	" 21	" 13	....	7480
17	Haverland	" 23	"	Large	" 21	" 13	....	8415
18	Monmouth	" 23	"	" tender	" 20	" 6	"	9350
19	Wilson	" 24	"	"	" 23	" 8	....	7480
20	Warfield	" 27	"	"	" 28	" 13	....	8415
21	Nectar	" 27	"	Small	" 26	" 6	Poor	1870
22	Gold	" 27	"	"	July 1	" 10	....	2805
23	Prince of Berries	" 26	"	Large	June 22	" 13	....	11220
24	Pine Apple	" 25	"	Small; tender	" 20	" 9	....	4165
25	Parker Earl	" 23	"	Small	" 20	" 9	....	5610
26	Chas. Downing	" 23	"	"	" 25	" 6	....	*
27	Parry	" 23	"	"	" 25	" 6	....	*
28	Dayton	None	"	Tender	None	.....	....	*
29	Morley	"	"	....	"	.....	....	*
30	Crimson Cluster	May 26	"	Large	June 23	" 12	....	7480
31	Stayman's No. 1	" 25	"	Large; tender	" 20	" 13	....	9350
32	Stevens	None	May 20	....	None	.....	....	*
33	Shuster's Gem	May 26	" 20	Large	June 23	" 9	Good	5610
34	Iowa Beauty	" 27	" 20	Short	" 24	" 15	"	6885
35	Viola	" 25	" 20	Small	" 26	" 10	Poor	6545
36	Lovett's Early	" 24	" 20	Tall	" 28	" 13	....	7480
37	Edgar Queen	" 24	" 20	Short	" 28	" 18	....	10285
38	Florence	" 30	" 20	Small	" 28	" 14	"	5610
39	Jucunda Improved	" 26	" 20	Very short	" 23	" 17	Good	11645
40	Yale	" 31	" 20	Tall; tender	" 30	" 9	....	4165
41	Standard	" 27	" 20	" "	July 1	.....	....	*

*On account of the very poor stand of these varieties, the yields were not computed.

FRUIT GROWERS IN SHERIDAN COUNTY.

So many farmers in Sheridan county are raising small fruits in their gardens that we do not attempt to give a complete list of names. There are some small orchards in the valleys of the Tongue river, Little and Big Goose, Prairie Dog and Piney creeks, from which we have been unable to obtain reports. We learn that Mr. Duval of Dayton has a producing orchard on Wolf creek. Arthur H. Senff of Kearney, Johnson county, has an orchard of apples, plums, and cherries. Thomas Connolly of Big Red and Dell M. Ray of Banner, are raising apples. M. L. Sawin of Sheridan has raised fruits for a number of years for the Sheridan and Buffalo markets. The letters given below, with accompanying illustrations, explain themselves.

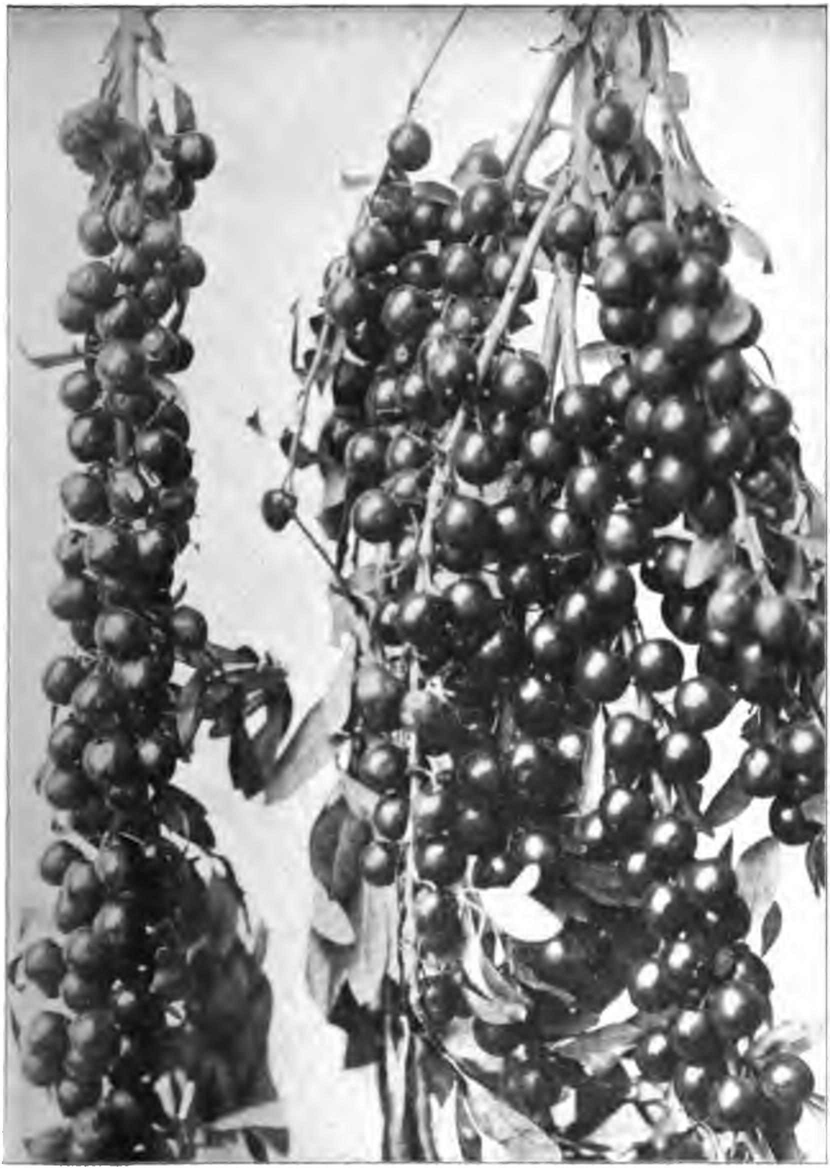
Letter from G. W. Barlow, Sheridan, Sheridan County.

"I have delayed answering your letter, hoping to give you a detailed description of some Sheridan county apple orchards, gathered from personal inspection, but so far I have not been able to get away from my work to visit the different people who are growing apples in this county. That they do grow and produce abundantly is a well demonstrated fact, and in such range of varieties as to insure with reasonable care a supply of choice fruit the year around. With the first summer apples brought into Sheridan that were raised in this county this year there were also brought samples of good apples grown last year and kept till August of this year. Of the varieties grown, I can recall having seen Wealthy, Ben Davis, Pewaukee, Hibernal, Red Astrachan, Duchess, Tetofsky, Yellow Transparent, Gideon, Moscow, Alexander; Crabs—Transcendent, Hyslop, Whitney, Gen. Grant, Yellow Siberian, and other varieties of standards, the names of which I do not now recall.

"The future of apple growing in northern Wyoming appears to be fully as promising as the early history of northern Colorado was in '72 or even later. I see the same conditions prevail to a great extent, and I hear the same prophecies as to the ultimate success of the business as I did there. Everyone who has seen Colorado lately knows that well up to its northern line apples are growing and producing large crops. We will do as well here in a few years, and I think an important point in this connection is to grow our own trees here in the country where we wish to plant them. They are then used to our climatic conditions, altitude, irrigation, etc., and are free from disease and not injured by long shipments. We have a good start in that direction now and will soon grow all our own trees. With proper selection of varieties, plenty of water, good native grown trees and good care, we can grow all the apples we want and some for other people.

"Small fruits all do well here, strawberries and raspberries especially. There were at least 10,000 boxes of strawberries sold and shipped at Sheridan this season. There are few people who raise raspberries for market, owing to the trouble of covering in winter. I know of one block of red raspberries of an acre and a half that yielded 2,000 boxes in 1896 and this year (1897) about 4,000 boxes.

"The Dwarf Rocky Mountain Cherry (Prunus Bessei) I have grown here for five years. It has never failed to produce fruit abundantly; it is never protected in winter and never winter kills; comes into bearing at two or three years of age and bears every year. The fruit ripens in August, from the middle to the last of the month, and will hang to the bushes till loosened by frost. The yield varies somewhat in different plants and in different seasons. I have picked twelve quarts from a three-year-old bush, but I have made no estimate as to the yield per acre. I set them eight or ten feet apart and like the plan of putting one plant between apple trees where the latter are about 18 or 20 feet apart. I think it would be a safe estimate to figure eight quarts per plant, set eight by ten feet to the acre.



ROCKY MOUNTAIN CHERRY. Sheridan, 1897. *Photo by Trone.*
Raised by Geo. W. Barlow.

"I believe we will yet raise an abundance of fruit here in northern Wyoming, which for quality and variety will astonish the oldest inhabitant. I am bending all my energies toward finding the hardiest and most desirable fruits for this country. I am anxious to keep in touch with all who are engaged in any horticultural pursuits, and will always do what I can to further horticultural interests in our state. I realize that this state is years behind other new states in horticultural advancement, and I would like to see a more general interest taken in matters of this kind. I believe there is a growing disposition among our residents to try fruit raising, where a few years ago it was taken for granted that 'Wyoming will never be a fruit country.' "

Letter from C. H. Manning. Sheridan, Sheridan County.

"Small fruits, such as currants, gooseberries, and strawberries, do well here. The varieties of strawberries I am growing are Parker Earl, Lady Rusk, Lovett's Early, Mitchel's Early, Wilson, and Gandy. The last-named variety secured the credit for the largest berry in a test inaugurated by the "Sheridan Post." Twenty-nine berries filled a quart box heaping full. Last season I raised some tame cherries, but can not give you the names of the varieties. I put out seven apricot trees in the spring of 1896 which have done extremely well.

"When quality, form, and color are taken into account, my apples will compare favorably with those from any state, and I believe I could compete successfully for size also. I have grown two varieties which have measured 12½ inches in circumference and weighed 15 ounces. I have an orchard of 175 trees which have been grown from root grafts purchased from F. S. Phoenix, Bloomington, Ill. I obtained several varieties to experiment with, some of which have been thrown over the fence. I now claim that I have apple trees that are tougher than our native timber, and I can grow them where I cannot grow yellow cottonwood. I have the Yellow Transparent, Antonovka, Tetofsky, Moscow, Enormous, and Hibernal, all Russian, and I believe that most of these will bear apples if it freezes from six to ten degrees while they are in blossom. The Moscow and Hibernal will blossom on yearling wood. The Moscow is an early apple, ripening about the 20th of August, and is very nice. Hibernal is one of the best cooking apples. It ripens the last of September. The Antonovka grown in this climate is a most excellent eating apple, as rich and of as fine quality as one could expect anywhere, and I think I can count on a crop five years out of six. Besides the above, I have the Red Astrachan, Wealthy, Wolf River, and Gideon, which are nice eating apples. The trees missed bearing only one year (I think 1892) since they were old enough. This year I sold some apples which had been kept eleven months, that were perfectly good and sound.

"I have a young orchard of 225 trees which I expect will begin to bear next season. They are mostly of the varieties I have named. There are 50 Wealthy, and some McMahon, Switzer, and Plum Cider. The last named is not hardy. The old orchard was planted nine years ago last spring. They were root grafts with one bud above the ground. When two years old they were set out in the orchard, but I think it would have been better had they been transplanted after one year.

"I sold four loads of apples this season. For one load I received five cents per pound, for another load four cents per pound, and for a third load $1.25 per bushel. The only photographs I have of my fruit trees are a couple of Kodak pictures, which do not show the fruit very well, although the trees are breaking down with it. One is of Wealthy and the other of Antonovka apples. I send them to you with the hope that you may be able to use them."

ANTONOVKA APPLES. *(Photo by Trone.)*
Raised by C. H. Manning, Big Horn, Sheridan County, 1897.

WEALTHY APPLES. *(Photo by Trone.)*
Raised by C. H. Manning, Big Horn, Sheridan County, 1897.

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SUNDANCE.

The agricultural lands around Sundance have an altitude of between 4500 and 5000 feet. The climate differs from that of other parts of the state principally in the rainfall, which averages about seventeen inches per annum in this section. Irrigation is not practiced. The valleys are well protected by the surrounding mountains, and in these valleys water is found at no great depth from the surface. The soil is red sandy loam containing a large amount of gypsum, but with no gravel or coarse sand. It is almost identical with the soil upon the Lander experiment farm.* The flora of the region differs from that of other parts of the state, as evidenced by the presence of scrub oaks, white birch, and viburnums.

Fruits Upon the Experiment Farm.

The experiment farm was established in 1891, and in 1892 the same varieties of fruits were planted as upon the other sub-stations. A large part of the stock ordered was so long on the road that it did not grow when set out. Good records of the fruits were kept the first year, but the varieties of small fruits were not permanently labeled. Through accidents which usually happen to small labels, they were lost. We have been unable, therefore, to locate the different varieties, and it has been impossible to report the results of the fruit experiments. From the superintendent's notes for 1893 and notes taken by the writer in 1895, we make the following brief report.

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*See Bulletin No. 6, page 20, and Bulletin No. 14, page 114.

ORCHARD FRUITS.

Apples.

Of the apple trees set out in 1892, the Wealthy all lived the first year. Fifty per cent of Ben Davis and thirty-three per cent of Gano also lived. The Oldenburg and Yellow Transparent all died. Yellow Transcendent, Whitney, Hyslop, and Martha Crabs lived and made good growth. Notes in 1895 show Wealthy and Ben Davis the most hardy standard sorts. Whitney and Hyslop Crabs were in bearing in 1895.

Cherries.

Early Richmond was most hardy, none of the trees having been winter killed. One Ostheim was in good condition. The tops of English Morello died down to the ground each winter.

Pears.

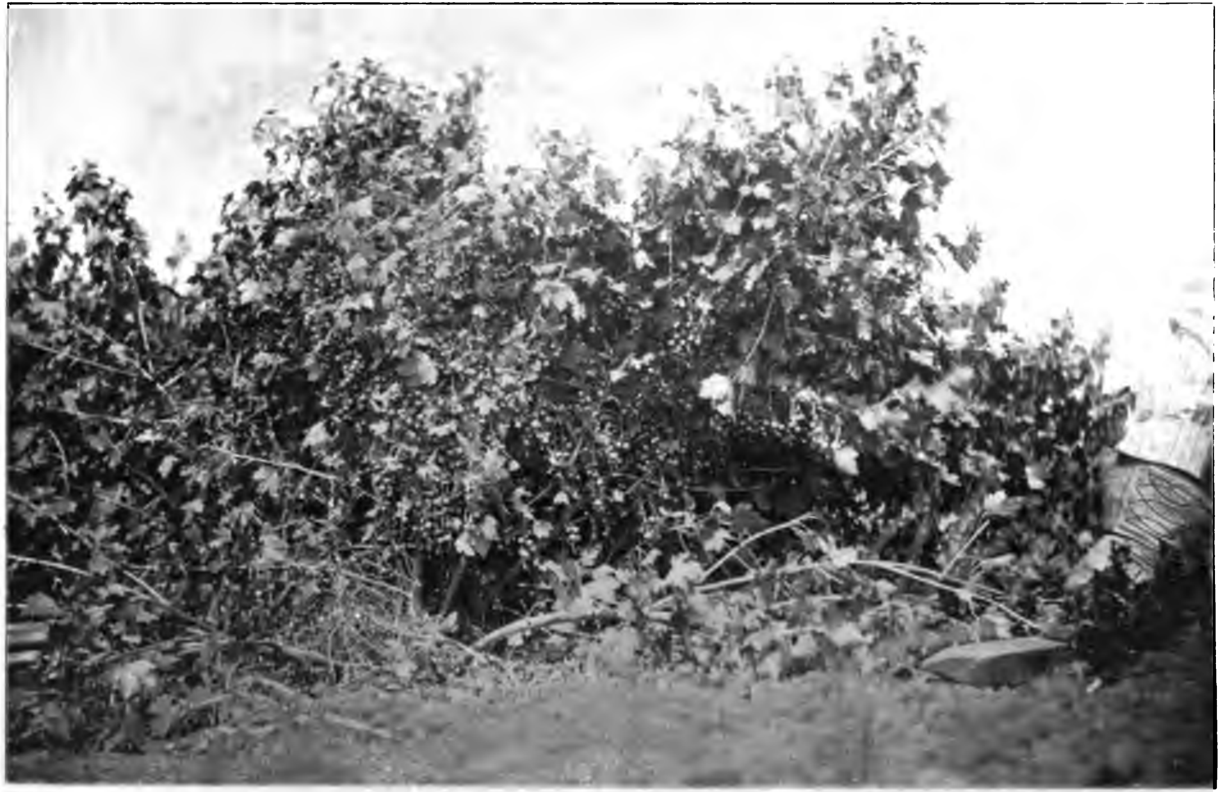
Flemish Beauty pear was most hardy and thrifty, having produced fine trees. Clapp's Favorite was second in hardiness but made rather slow growth. Bartlett, Keiffer, Gakovska, and Bessemianka died down to the ground each winter.

Plums.

Weaver and De Soto plum trees seeemed most hardy, there being good, stocky trees of each variety. One Hawkeye plum tree was in a thrifty condition, the others having made small growth.

SMALL FRUITS.

We are unable to make a detailed report upon the varieties of small fruits. Currants and gooseberries succeeded well and bore heavy crops. The Crandall currant, which we consider the best black variety, was very prolific. We show an illustration of this variety, the limbs being raised to show the fruit. The red and white varieties also bore heavy



CRANDALL CURRANT. Sundance, 1895

crops. The gooseberries do not seem quite so hardy as the currants, but all the varieties bore well. The Downing is the favorite among those tried.

Blackberries, raspberries, and strawberries gave creditable crops, but no records were kept of them.

FRUIT GROWERS IN CROOK COUNTY.

A letter from Hon. A. E. Hoyt states that no one in the immediate vicinity of Sundance has raised any amount of fruit. Mr. Meeks, in the city, has a few fine trees. His Siberian and Transcendent crab trees have borne fruit several years.

Mr. Hoyt states that Mr. J. Eaton of Sand creek has about 150 fruit trees and has raised some fine apples. Mr. Bush of Hulett has about 500 young trees and expected to harvest some apples this season.

We know that with proper care the hardy apples, cherries, and plums, and all the small fruits, will succeed in this part of the state.

WHEATLAND.

The town of Wheatland is at an elevation of 4700 feet and is surrounded by a large tract of fertile farming land.

The Wheatland district is east of the Laramie range of mountains and has much the same climatic conditions as western Nebraska. The soil is colluvial upland and remarkably free from alkali.* The land is irrigated with water taken from the Laramie and Sybille rivers. A large number of farmers have settled upon the lands around Wheatland in the last three years, and many of them are planting orchard and other fruits.

Fruits Upon the Experiment Farm.

The station farm was located in 1891 and fruit plantings begun in the spring of 1892. The farm is on the open plain, and at the time the fruits were planted there was no protection from winds. The trees growing up around the farm have been large enough for two or three years to break the force of the winds to some extent.

ORCHARD FRUITS.

As a rule, the stock purchased was in excellent condition and the loss of trees in the orchard has been remarkably light. In no part of the state have the trees set out in the orchard succeeded better or the outlook been more encouraging than upon the Wheatland farm. The only mishap to the orchard was a hail storm destroying the young fruit in 1896. This season we have been unable to obtain

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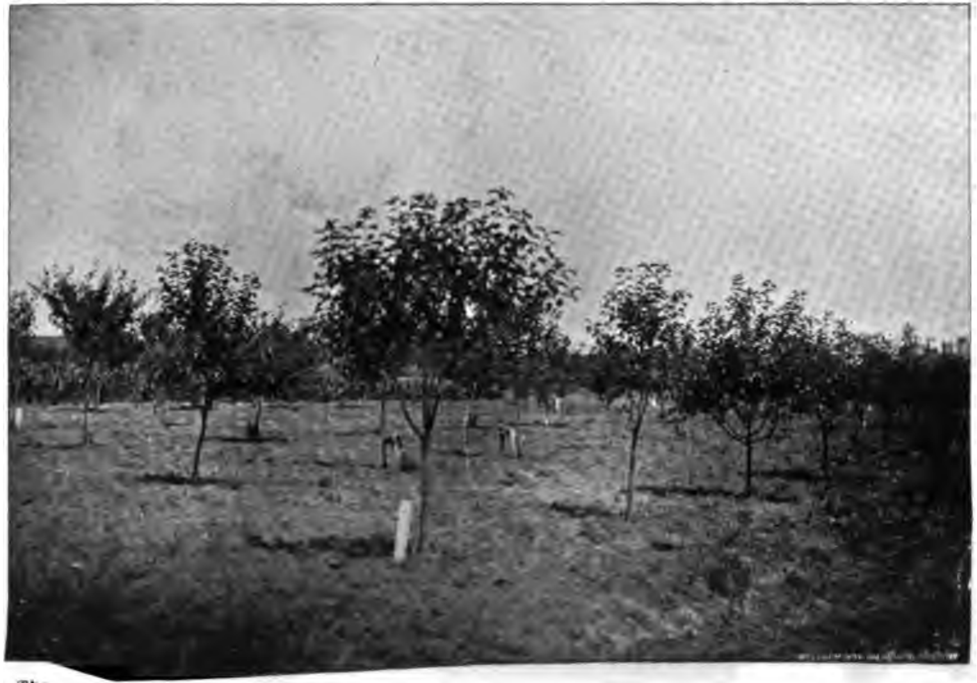
*See Bulletin No 6, page 21, and Bulletin No. 14, page 116.



Three Year Old Orchard at Wheatland, 1895.

(Cut loaned by Hon J. M. Carey.)

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a full report of the fruits, as the farm has not been in charge of the Station. The storm of September 20, 1895, which was so destructive in other parts of the state, caused comparatively little damage to the orchard at Wheatland.

Our illustration of the orchard when it was three years old was kindly loaned to us by Hon. J. M. Carey. The report for 1895, as made by the superintendent, M. R. Johnston, gives the results up to that fall, and Mr. Carey's letter indicates which of the varieties fruited this season (1897). In pruning the trees, care was taken not to remove any branches on the south and west sides, leaving them to protect the trees as much as possible from being burned by the sun.

In the notes for 1895, we copy the record as made by the superintendent in the fall of that year.

Apples.

The trees given in the following notes were planted in April, 1892. In 1895 the mulching was removed from around the trees and tar paper wrapping taken off April 20. The ground was cultivated once a week from April 1 to August 6, being kept in a good state of tilth and perfectly free from weeds. Owing to the thorough cultivation, but little irrigation was necessary, and they were irrigated only twice, May 24 and September 25. The winter protection given was a heavy mulch of coarse manure, and on October 30, 1895, a box made of one by three inch boards was placed around the trunk of each tree to keep the bark from sunscald and injury by rabbits. Before 1895 tar paper was used each winter for the same purpose, but the tar paper proved more or less injurious where it came in contact with the tree.

NOTES FOR 1895.

GANO.—Six trees were planted. All are alive and thrifty. Average diameter of trunks, two and three-fourths inches. Height of trees, five feet. They came into leaf May 1 and made a season's growth of twelve inches.

BEN DAVIS.—Six trees were planted. All are healthy and in good condition. Average diameter of trunks, two and one-third inches. Height of trees, eight feet. Came into leaf May 1 and made a season's growth of three and one-half feet.

OLDENBURG.—Five trees were planted. Four are alive, with short trunks, and thrifty, bushy tops. Diameter of trunks, two and one-fourth inches. Height of trees, five feet, two inches. They came into leaf May 3 and made a season's growth of fifteen inches.

RED ASTRACHAN.—Five trees were planted. All are alive, strong, and thrifty. Diameter of trunks, two and one-half inches. Height of trees, seven feet. Came into leaf May 3 and had a few blossoms, but fruit fell off when small. Season's growth, twenty-six inches.

WEALTHY.—Six trees were planted. All are alive and thrifty. Diameter of trunks, two and one-half inches. Height of trees, seven feet. Came into leaf May 3 and had a few blossoms, but fruit fell off when small. Season's growth was twenty inches.

YELLOW TRANSPARENT.—Six trees were planted. Five are alive and in excellent condition. Diameter of trunks, two and one-fourth inches. Height of trees, five feet. They came into leaf May 3. Season's growth was fourteen inches.

HYSLOP CRAB.—Five trees were planted. All are alive and very thrifty. Diameter of trunks, two and one-half inches. Height of trees, seven feet. Came into leaf May 3. Season's growth, three and one-half feet.

WHITNEY CRAB.—Six trees were planted. All are alive, strong, and thrifty. Diameter of trunks, two and one-

J. L. BUDD APRICOT TREE. Wheatland, 1895.
(Cut loaned by Hon. J. M. Carey.)

fourth inches. Height of trees, six feet, two inches. Came into leaf May 3. Season's growth, forty inches.

MARTHA CRAB.—Six trees were planted . Five are alive and in good condition. Diameter of trunks, three inches. Height of trees, seven feet, two inches. They came into leaf May 6. Had a few blossoms and some apples formed but fell off when small. Season's growth was twenty-five inches.

Apricots.

Variety.	No. set out.	No. living.	Diam. of trunk, inches.	Height, feet.	Came into leaf.	Season's growth, inches.
Abundant*	6	5	2.3	5.2	May 3	14
Gibb†	2	2	3.0	9.0	" 9	24
Alexander	2	2	2.25	10.0	" 9	27
Russian	3	2	1.3	4.0	" 7	13

*Probably Abundance plum.

†Our illustration of this variety was made from a photograph taken in 1895, instead of 1897 as indicated on the plate.

Cherries.

EARLY RICHMOND.—Six trees were planted. All are alive and in good condition. Diameter of trunks, three inches. Height of trees, six feet. They came into leaf May 1 and into bloom May 5. Season's growth was fifteen inches. The fruit was ripe July 4. Birds destroyed most of the fruit as fast as it ripened. Fruit large, dark red color, of fine flavor.

MORELLO.—Six trees were planted, all of which are alive and thrifty. Diameter of trunks, two and one-half inches. Height of trees, six and one-half feet. They came into leaf May 1 and into bloom May 7. The season's growth was fourteen inches. The fruit was ripe July 20. Birds destroyed the fruit.

INTORKA.—Three trees were planted. All are alive. Diameter of trunks, three inches. Height of trees, five feet, two inches. They came into leaf May 3 and had a few blooms May 5, but matured no fruit. Season's growth was thirteen inches.

OSTHEIM.—Three trees were planted. One is living. Diameter of trunk, three inches. Height of tree, five feet. Came into leaf May 5. Had a few blossoms May 5. Fruit ripe July 4. Fruit destroyed by birds.

ROCKY MOUNTAIN.—Three were planted. Two are alive. A small bush with branches trailing on the ground. Height of bushes, twenty-eight inches. Came into leaf May 6 and into bloom May 6. The fruit was ripe August 10. Fruit of large size, black in color, and of fine flavor.

Pears.

Variety.	No. planted.	No. living.	Diam. of trunk, inches.	Height of trees, feet.	Came into leaf.	Season's growth, inches.
Bessemianka	3	2	1.6	6.5	May 15	15
Gakovska	3	3	1.0	4.5	" 3	13
Flemish Beauty	6	5	2.0	6.0	" 6	18
Keiffer	6	4	1.5	6.0	" 9	17
Clapp's Favorite	6	6	2.25	6.5	" 9	14
Bartlett	6	5	1.0	4.5	" 3	13

Plums.

HAWKEYE.—Six trees were planted. All are alive, and have made large, healthy trees. Diameter of trunks, three inches. Height of trees, seven feet, two inches. They came into leaf May 3 and were in blossom April 27. The season's growth was fourteen inches. The fruit was ripe August 26. The trees yielded two quarts each.

DE SOTO.—Six trees were planted. Five are alive and in good condition. The average diameter of the trunks is two inches. The height of the trees is eight feet. They came into bloom April 27, and into leaf May 3. The season's growth was twelve inches. The fruit was ripe August 30; the yield being six quarts. Fruit was not so good as that of Hawkeye.

WOLF.—Six trees were planted and all are alive and

ENGLISH MORELLO CHERRY IN BEARING. Wheatland, 1895.

thrifty. The average diameter of the trunks is three inches and the average height of the trees is seven feet, one inch. They came into leaf May 9. The season's growth was twelve inches.

SMALL FRUITS.

The small fruits have not succeeded so well as the trees, a much larger per cent of the plants set out having died. This is explained by the fact that the orchard was set out on a more favorable part of the farm. With the small fruits the winds of winter and early spring dried out and blew away the soil and whipped off the plants. They were all set out in April and May of 1892. Those which died have not been replaced, and there are undoubtedly many varieties in addition to those here reported which will succeed. However, those which we report as fruiting best are probably the most hardy and prolific of the kinds tried. All have been grown under the same conditions and have been treated as nearly alike as possible. Our report is based upon the superintendent's notes for the season of 1895. Those varieties of which all the plants died before that season are not mentioned.

None of the grapes succeeded. The dewberries are not mentioned in the report for the year. The small fruits were given clean cultivation with a horse cultivator and hoed each month during the summer. All were irrigated in furrows between the rows. The currants, gooseberries, raspberries, and blackberries were irrigated May 20, June 10, June 22, July 12, August 1, and September 28. The currants and gooseberries were protected through the winter with a heavy mulch of barnyard manure. The other fruits were laid down and covered with earth. The mulch was removed about the middle of April.

Currants.

WHITE GRAPE.—Twenty-four were planted . All lived. They came into leaf April 15 and into bloom May 3.

The fruit was ripe July 6. The yield averaged two and one-half pounds per bush or at the rate of 9075 pounds per acre where planted three by four feet apart. Fruit large and of excellent quality.

RED CHERRY.—Twelve were planted and all lived. They came into leaf April 15 and into bloom May 1. The fruit was ripe July 25. The average yield was four pounds per bush or at the rate of 14,520 pounds per acre. Berries small, light red, of excellent quality.

CRANDALL.—Twelve were planted, all of which are living. They came into leaf April 15 and into blossom May 1. The fruit was ripe July 10. Yielded an average of nine pounds for each bush, or at the rate of 32,670 pounds per acre. The bushes are very thrifty and prolific. Fruit large, black, and of good flavor.

LEE'S PROLIFIC.—Twelve were set out. Ten plants are living. They came into leaf April 15 and into bloom May 4. The fruit was ripe July 17. The yield averaged two and one-half pounds per bush, or at the rate of 9,075 pounds per acre. The fruit is black, of medium size, and poor quality.

Gooseberries.

DOWNING.—Twenty-four plants were set out. All are alive. They came into leaf April 24 and into bloom May 8. The fruit was ripe July 23. The average yield was six pounds per bush, or at the rate of 21,780 pounds per acre. Berries large, light green, of fine flavor, flesh soft; a prolific cropper.

HOUGHTON.—Twelve plants were set out. All are living. They came into leaf April 15 and into bloom April 26. The fruit was ripe July 20. The average yield was four and one-half pounds per bush, or at the rate of 16,335 pounds per acre. Fruit of medium size, flavor very fine; a good cropper.

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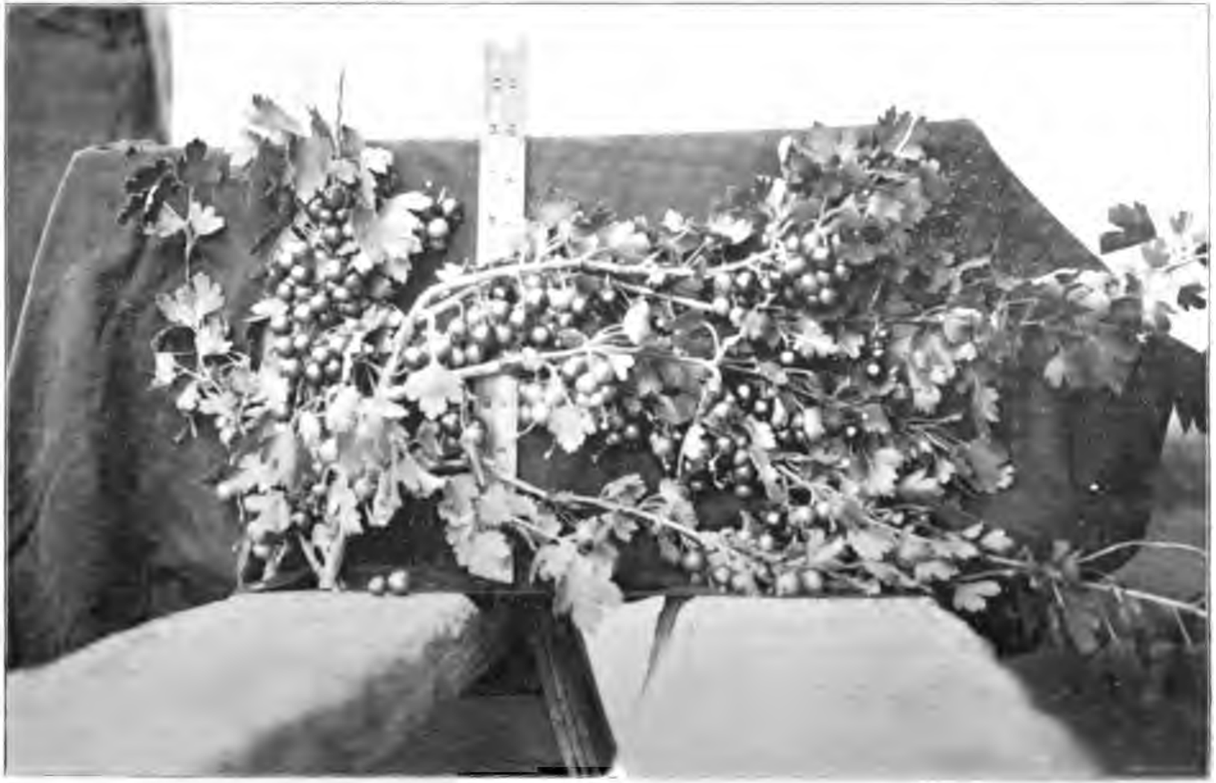

CRANDALL CURRANT. Wheatland, 1895.

Blackberries.

Stone's Hardy, Lawton, Lovett's Best, and Rochester did not bloom. These are named in the order of their apparent hardiness, the most hardy standing first.

EARLY KING.—Twenty-four plants were set out, all of which are alive. They came into leaf May 5 and into bloom May 25. The fruit began to ripen July 15 and yielded an average of three and one-half pounds per hill, or about 9,529 pounds per acre. The berries are large and of excellent quality. This is the best variety tried.

WILSON JUNIOR.—Twenty-four plants were set out. Fifteen are alive. They came into leaf May 3 and into bloom May 18. The fruit was ripe July 10. The berries are large and of good quality . The canes are large and thrifty, but not prolific.

Raspberries.

Golden Queen, Caroline, Brandywine, and Marlboro failed to bloom. Hansel came into bloom May 20 and Progress May 21, but they failed to mature fruit.

THOMPSON'S EARLY PROLIFIC.—Twelve were planted, ten of which are living. They came into leaf May 1 and into bloom May 20. The fruit began to ripen July 1 and yielded an average of two and one-half pounds per hill, or at the rate of about 6,806 pounds per acre. This is the only variety which produced fruit in 1895.

Strawberries.

The first strawberry plat was set out in May, 1892. It was in an unfavorable place and the vines made little growth during the three seasons that the bed was allowed to remain. On May 23, 1895, the young plants were taken from this plat and set in a new bed. No report has been obtained upon them since that time. Haverland has not been hardy. Other varieties which have succeeded best are Manchester,

Jucunda, Mitchel's* Early, Wilson, Florence, Lady Rusk, Charles Downing, Staymen's, Edgar Queen, Stevens, Shuster's Gem, Standard, Warfield, Pine Apple, Parker Earl, Crimson Cluster, Gold, and Crescent.

FRUIT GROWERS IN LARAMIE COUNTY.

Farmers around Wheatland are planting orchards and other fruits. These plantings are new, and but few of them have come into bearing. M. R. Johnston had raised some small fruits there before the station farm was established. Upon the Mule Shoe and the Two Bar ranches, west of Wheatland, some apples and other fruits have been produced. A number of people in Cheyenne are growing hardy apples and other fruits in their yards. Mr. John Gordon of Lower Horse creek sent us specimens of Oldenburg apples from his ranch this fall which we photographed for this report.

Letter from Hon. J. M. Carey, Cheyenne, Wyo.

"With reference to the fruit, I have to say that twenty odd plum trees of the De Soto and Wolf River varieties, on the land recently used by the University as the experiment farm at Wheatland, bore full crops of fruit. This fruit was of excellent quality. There were fifteen or twenty apple trees that produced fine apples; not full crops, however. These were of the Ben Davis, Wealthy, Northern Spy, and Pippin varieties.

"Mark Johnston says, however, that there were among these fully twenty varieties, the names of which I have not been able to obtain.

"On the Wheatland flats, Mr. Harper produced some fine standard apples of the Ben Davis and Pippin varieties. At the Mule Shoe ranch, several varieties of crab apples were produced in abundance.

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*This way of spelling Mitchel's, as given in "Thomas' American Fruit Culturist," is used throughout this bulletin. The favorite spelling is Michel's.

OLDENBURG APPLES, One-Third Natural Size.
Raised by J. N. Gordon, Lower Horse Creek, Laramie County, 1897.

GIBB APRICOTS. Wheatland, 1897.

"There were several parties in Cheyenne who produced apples this year. The mischievous boy, however, prevented very much of the fruit from maturing. Those that were left on the treees grew to a good size and were of fine quality.

"I had about a dozen trees, standard varieties, that produced fine apples, and so far as they were permitted to remain on the trees they matured. I had one tree of improved crab apples which grew to the size of an ordinary peach. The tree had as many apples as it could possibly carry. They matured and were a delicious eating apple. I had several trees of the smaller varieties of crab apples which produced full crops.

"The small fruits did exceedingly well in the Wheatland colony—gooseberries, raspberries, and strawberries. From what I have seen this year, I have no doubt that Wyoming will become a fruit growing state so far as the varieties which are common in this latitude are concerned."

Letter from J. N. Gordon, Lower Horse Creek, Laramie County.

"I have several varieties of apples, but the names have been lost, so I send you a sample by express, and from this you can get an idea of what success people may expect in raising fruit here. I am sorry your inquiry came so late, as I had several varieties, but they are all gone now except the ones I send you. Years ago I saw as fine grapes grown on a ranch close to my place as I have ever seen in the markets of Cheyenne. After nearly thirty years' farming in Colorado and Wyoming, I have arrived at the conclusion that I can raise on my ranch on Lower Horse creek any of the fruits that can be raised in the Cache la Poudre valley in Colorado."

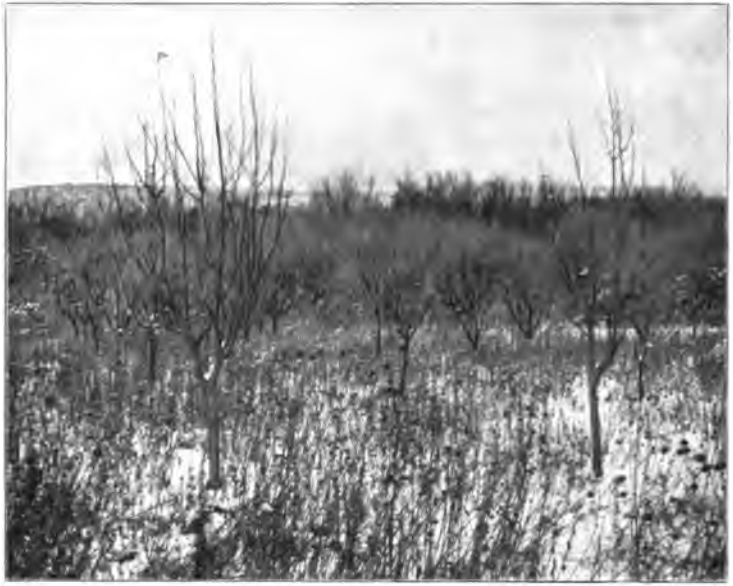
Fruits in Other Parts of Wyoming.

In Weston, Sweetwater, and Uinta counties, practically no attempts have been made to raise any kind of fruit. In Converse county almost no fruits have been raised. Mr. F. Lusk of Lusk has a few apple trees in bearing. We learn that some fruits have been planted in the vicinity of Douglas and in the La Prelle valley. In Natrona county, some farmers in the vicinity of Casper have young orchards set out. W. A. Blackmore of Casper states that he has recently made plantings of apples,plums,graps,and other small fruits. B. B. Brooks states that he has been quite successful with strawberries and other small fruits, and that upon nearly all the ranches in that section small fruits are raised for home use. Mr. J. Milne of Casper has a small orchard.

In Big Horn county there are a few small orchards. With the exception of the following letters, we have been unable to obtain reports from that section.

Letter from J. H. Taylor, Bonanza, Big Horn County.

"There are several small orchards in the Big Horn basin that have borne fruit for several seasons, and of the choicest kinds. I have been in the business only two years and have had more stock than I could get set out each season. From the late arrival of stock in the spring I have lost a good many, but I have an orchard of several kinds of apples, pears, and plums, besides the small nursery stock, which includes fancy shade trees. The main orchard is doing finely and will begin to bear next year. It consists of over four hundred trees. I am satisfied that this country will grow all of the hardy varieties and that the fruit will be of superior flavor and size."



Orchard of Mr. James Cantlin, Ferris, Carbon County, November, 1897.
(*Photo by W. C. Knight*)

Letter from J. C. Morgan, Jordan, Big Horn County.

"I have tried several kinds of fruits here. All small fruits, such as strawberries, currants, gooseberries, raspberries, and grapes have done well. Many of my first trees of apples, crabs, cherries, and pears have been winter killed. Those farmers located nearer the mountains whose places are 200 or 300 feet higher than mine have raised fine apples, crabs, and plums. Berries do well in all parts of the county. There is quite a variety of native fruits here. I think this will be a good fruit county when we learn how to handle our trees under irrigation."

In Carbon county a number are raising some fruits. The fruits upon the Saratoga experiment farm were not grown long enough to determine what would succeed. J. D. Parker, who was superintendent, states that currants and strawberries have been successful. We show an illustration of the orchard of Mr. James Cantlin of Ferris, which has borne a good crop of apples. We have not learned the varieties. This orchard was set out seven years ago and has not been given much attention. In Rawlins and vicinity, almost no attempts have been made to raise fruits, though in 1895 we learned of some cherry trees in town which were in bearing.

CONCLUSION.

We dedicate this bulletin to the farmers and ranchmen of Wyoming. We have avoided technicalities and have attempted to make this a popular report for the exclusive benefit of our own people. Should it find a wider use than this, we shall be pleased, but we do not expect it. Other station workers will find no new experiments reported that add to the knowledge of the day, but the bulletin will convey to them an idea of the horticultural possibilities of our great, new state. We have attempted to indicate the present condition of horticulture in the state and point out the success which will attend the careful grower who wishes to raise fruits within our borders. As it is our first bulletin upon this subject, we have reported all the experimental work attempted, whether or not important results were obtained, and have tried to make it representative of the present stage of our fruit industry.

Our photographs are an accurate and important part of our notes and records, and the conclusions to be drawn from them are as important as facts derived from the text. There is no possibility of misconstruing them, and so far as they illustrate any phase of the subject, they have been reproduced for this bulletin. True, we expect them to be more generally read than the written matter and they represent only successes, but the negative results of our experiments are given proper place.

We are hardly in a position to recommend varieties of fruit for a farmer to plant, However, we do not hesitate to name the varieties which we know to be hardy and prolific in our climate. At present it is not a question of whether we like the flavor of Bellflower apples better than that of Ben Davis, but rather whether we prefer the hardy varieties to no apples at all. It is safe to say that all the fruit raised in our state for many years to come will find a ready market at home. The better the quality, the higher the price it will bring.

The time will soon come, if indeed it is not now at hand, when our fruit growers should organize for the advancement of their own interests and for mutual protection. Concerted action from this time forward should effectually prevent insect enemies or fungus diseases from becoming serious pests in the state. When once such pests obtain a secure foothold, it is not an easy matter to keep them in check. There are many other advantages to be derived from such an organization.

The following kinds and varieties of fruits have proved to be hardy and prolific in sections which represent the larger portion of the state. Apricots and pears have not yet fruited, though the trees of a few varieties seem perfectly hardy. This list includes only varieties which have generally succeeded, and, with the exception of grapes, they may, with considerable assurance of success, be planted in sheltered localities up to an altitude of something over seven thousand feet.

Apples.—Wealthy, Oldenburg, Ben Davis.

Crab Apples.—Siberian, Martha, Transcendent, Hyslop.

Cherries.—Rocky Mountain Dwarf, Morello, Early Richmond.

Plums.—De Soto, Weaver.

Blackberries.—Early King, Stone's Hardy, Wilson Jr.

Dewberries.—Lucretia, Mammoth.

Currants.—Red Cherry, White Grape, Crandall, Lee's Prolific.

Gooseberries.—Houghton, Downing.

Grapes.—Concord, Wyoming Red, Delaware.

Raspberries (yellow.)—Caroline, Golden Queen.

Raspberries (red.)—Turner, Hansel, Thompson's Early Prolific, Marlboro.

Raspberries (black.)—Kansas. Progress, Gregg, Lovett.

Strawberries.—Nearly all varieties are sufficiently hardy. The notes at Lander and Sheridan show which have been earliest, most prolific, of the best quality, and the best for shipping.

UNIVERSITY OF WYOMING.

Agricultural College Department.

WYOMING EXPERIMENT STATION,

LARAMIE, WYOMING.

BULLETIN NO. 35.

DECEMBER, 1897.

Mechanical Analysis and Water Content of Wyoming Soils.

BY C. B. RIDGAWAY.

Bulletins will be sent free upon request. Address: Director Experiment Station, Laramie, Wyo.

Wyoming Agricultural Experiment Station.

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Introduction.

The objects of this bulletin are to show the results of a mechanical analysis of some typical soils of Wyoming, comparing them with typical soils from the humid regions; and also to show the moisture content of the soil of the Laramie Experiment Farm during the growing season.

The method used in making the analysis and in determining the amount of moisture in soils in the field are those described in Bulletin No. 4, U. S. Department of Agriculture, Department of Agricultural Soils, 1896.

I am greatly indebted to Prof. B. C. Buffum, Agriculturist of this Experiment Station, not only for having collected the samples of soil from the different experiment farms, but also for the very complete set of notes which he took at the time and kindly turned over to me for use in the preparation of this bulletin. Acknowledgment should also be made of the patient and faithful work rendered by my assistant, Mr. Joseph Orr, without whose aid the work could not have been completed so quickly.

Mechanical Analysis of Soils.

BY C. B. RIDGAWAY.

The soil is generally defined as the loose earth which covers the rocks to the depth of from a few inches to many feet and furnishes most of the nourishment for growing plants. In the Atlantic coast regions that portion of the earth which is cultivated by the plow, and which extends to a depth of from six to twelve inches, is generally termed the soil, while all below that is called subsoil. The reasons for this distinction arise from the fact that the subsoil when first brought to the surface generally proves very unproductive, for a short time at least after exposure, and from the other fact that there is usually a very noticeable difference in color between the two kinds of soil. In the arid regions, however, these characteristics almost entirely disappear, for in many localities no difference in color is to be noticed from the top of the ground to the solid rock, and in many places when the soil has been brought from a depth of twenty and even thirty feet it has often proved as productive as the surface soil of the same region. This peculiarity of the soils of these regions where irrigation is so indispensable is of inestimable importance. Hillocks are leveled and hollows are filled; thus bringing much of the ground, which otherwise would remain barren, under cultivation.

All soils have been formed from rocks by means of various agencies. The chemical action of the different gases in the atmosphere, the mechanical action of freezing water, wind erosion, water erosion, the roots of plants entering the seams in the rocks and forcing them apart, but especially the great ice plows of the glaciers leveling mountains and filling valleys—all these have been through countless ages, and still are, at work making soil of the solid rocks. In some cases the soil has been formed in place by the decomposition of the underlying rock, but in others it differs materially from the rock upon which it rests. In the latter case very frequently the soil has been brought from a great distance, either by means of glaciers or running water, and deposited in its present position.

It is a fact now generally conceded by most agriculturists, that a soil may have all the chemical elements necessary for the production of good crops, and yet, unless the physical texture is of the proper quality very inferior crops will be obtained. In view of this fact it is now deemed necessary to make both a chemical and a mechanical analysis of the soil in order to arrive at a just estimate of its productiveness and adaptability to certain crops. The object of the mechanical analysis of the soil is the quantitative determination of the coarsesr and finer material entering into its composition. Only soil whose grains are less than two millimeters (1-12 inch) in diameter, called fine earth, is used for this purpose; all over this size is considered coarse gravel, which is incapable of furnishing any nourishment to plants till further disintegration takes place.

Following the method used by the U. S. Department of Agriculture, I have divided the fine earth into these eight classes:

Diameter in millimeters.	Conventional name.
2-1	Gravel
1-.5	Coarse sand
.5-.25	Medium sand

Diameter in millimeters.	Conventional name
.25-.1	Fine sand
.1-.05	Very fine sand
.05-.01	Silt
.01-.005	Fine Silt
.005-.0001	Clay

It has been found by experiment in the Atlantic Coast States, and in fact in most humid regions, that a sandy soil is best adapted to raising truck, heavy loam to wheat, while a stiff clay has been found best suited for grass land. Some have concluded from this now apparently established fact that in all of the unoccupied regions of the west the soil could very readily be analyzed and prospective settlers assured as to the adaptability of certain soils to certain crops. This method of reasoning, however, will not hold for the arid regions, where the farmers depend almost entirely for their water supply upon irrigation.

The adaptability of the stiff clay lands of the east to the raising of grass depends upon the fact of their retaining more moisture near the surface for nourishing the grass roots than any other variety of soil. In the arid regions, however, some of the very best yields of grain and grass have been obtained from sandy soils by the aid of irrigation. From this we infer that every typical region must work out its own typical soils by the aid of chemical and mechanical analyses coupled with actual experiment. One of the main objects of this bulletin is to classify the soils of Wyoming, if possible, under their various types.

Thirty samples of soil were collected from five of the best agricultural sections of the state. After the soil had ample time to air-dry, the contents of the sacks (holding about twenty-five pounds each) were emptied upon a table covered with oil-cloth, and after thoroughly mixing divided into four equal parts. One of these parts was taken as a sample and all of the lumps pulverized with a rolling pin covered with thick sheet rubber to prevent crushing the grains of sand. The soil was then passed through a sieve punched with round holes two millimeters in diameter, and after all the coarse gravel which remained in the sieve had been washed, dreid, weighed, and its percentage of the soil calculated, the fine soil was placed in large glass jars which were corked and labeled for future use. A subsample weighing 20 grams was afterwards taken and washed into a long glass bottle, such as is used in sterilizing milk, which was filled half full of pure water and securely closed with a rubber stopper. Ten such bottles with their contents were placed in a shaker of my own construction which had a throw of about six inches and made 150 revolutions per minute. The shaker was kept in constant motion from 24 to 48 hours, according to the nature of the soil, by means of a small water motor. The object of this shaking was to disintegrate all the particles of the soil, so that instead of many conglomerates, which would lead to much difficulty, if not to false conclusions, there might remain only separate grains. After the soil had been washed from the bottles into beakers it was carefully examined under a microscope, and if not thoroughly disintegrated hand pestling with a rubber-tipped pestle was resorted to for a short time to complete the work. The soil was then separated into eight grades by the "Beaker Method."

To aid in forming a more correct idea of the relative amount of grains of various sizes entering into the composition of the different soils, samples of the separations of the different grades of material from each of the five experiment farms were placed into small bottles, mounted on cards and photographed. Besides the eight bottles containing soil, two others appear in the illustrations—the ninth showing the amount of moisture contained in the air-dried sample, and the tenth the amount of organic and volatile matter.

Doubtless the contents of the last bottle is somewhat exaggerated, as I have used walnut sawdust to represent the organic and volatile matter.

In taking the samples, all litter was first removed from the surface and then a hole was dug with a shovel to a depth of three feet on three sides of a column of soil about one foot square at the top. This column was afterwards trimmed down with a sharp spade to a size six inches square. The surface soil of this column to a depth of one foot was removed and placed in a sack 6x12 inches, which sack was numbered, labeled, and securely fastened. Immediately below this sample the column was carefully removed from a depth of one foot to a depth of two feet and placed in another sack. In this manner six samples were taken from each of the farms—three of the surface soil and three of the subsoil. The sacks were so numbered that all of the surface soils were marked with odd numbers and the subsoils with even numbers.

Soil from the Wheatland Experiment Farm.

The Wheatland Experiment Farm is situated in the eastern portion of Wyoming on what is knows as the "Great Plains," at an elevation of 4,700 feet. The soil of this farm is a colluvial deposit derived from the Archaean and Pliocene rocks, without any glacial action however, and resting upon a Pliocene conglomerate.*

The ground selected for taking the first two samples was the prairie sod, on which were found growing buffalo grass (*Bulbilis dactyloides* (Nutt) Raf.), three-leafed sedge (*Carex filifolia*, Nutt), and an occasional spear of *Stipa comata*, Trin. The soil was dry and hard to dig (it was dug the 7th of August), but became a little moist at a depth of one foot. Two feet below the surface a bed of cement gravel was found containing stones of granite, orthoclase, labradorite, magnetite, schist, quartz, and lime incrustations on granite. The top soil was of a dark gray color, but became much lighter in color the farther down it was dug. Samples 3 and 4 were taken from a plat which had been cultivated but not fertilized. The plat had been irrigated on May 20, June 15, and July 8, on account of which the samples were quite moist and easy to dig. No gravel was found in these samples. Samples 5 and 6 were taken from a plat which had been both cultivated and fertilized. The plat had received its last irrigation on July 16th, on account of which the subsoil was very wet and stuck to the shovel. The soil was full of lumps which were very difficult to crush with the unaided fingers. These lumps absorbed water very rapidly and became quite soft and plastic. The soil contained about .6 per cent of coarse gravel.

On making a mechanical analysis, the following results were obtained:

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*See Bulletin No. 14, page 116.

No. of Sample		Locality	Gravel (2-1 mm.)	Coarse sand (1-.5 mm.)	Medium sand (.5-.25 mm.)	Fine sand (.25-.1 mm.)	Very fine sand (.1-.05 mm.)	Silt (.05-.01 mm.)	Fine silt (.01-.005 mm.)	Clay (.005-.0001 mm.)	Moisture in air-dried sample	Organic and volatile matter.	Loss.
Top soil (0-12 in.)	Subsoil (12-24 in.)												
			Per cent.	*Per cent*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1		Wheatland	1.205	2.155	11.925	20.205	39.010	2.995	2.180	15.400	2.040	2.060	0.825
	2	"	0.915	2.100	10.025	18.360	41.380	2.150	1.205	15.610	2.000	2.160	4.095
3		"	1.975	2.555	10.840	15.220	39.090	3.775	1.625	17 165	1.480	3.260	3.005
	4	"	0.390	0.965	4.940	13.230	49.245	6.305	5.880	11.400	2.000	3.320	2.325
5		"	1.620	2.610	10.205	17.270	36.880	5.165	1.710	17.300	2.620	3.180	1.440
	6	"	0.240	0.745	3.675	6.305	35.360	16.695	13.420	14.280	2.660	3.600	3.050
		Average	1.057	1.855	8.601	15.095	40.161	6.181	4.339	15.192	2.133	2.930	

The crops raised upon this farm and the greatest yield per acre during three years is shown below.

Alfalfa	8,732 lbs.	Oat	74.2 bush.
Barley	50 bush.	Onion	93,492 lbs.
Bean	26 bush.	Parsnip	9,854 lbs.
Beet	43,776 lbs.	Pea	17 bush.
Broom corn	2,240 lbs.	Peanut	1,740 lbs.
Buckwheat	28 bush.	Potato	25,740 lbs.
Cabbage	34,362 lbs.	Rye	31 bush.
Carrot	75,240 lbs.	Sweet potato	3,200 lbs.
Corn	48 bush.	Sugar beet	24,000 lbs.
Flat pea	1,545 lbs.	Turnip	12,869 lbs.
Flax	14 bush.	Wheat	50 bush.

The following are the average yields per acre for the same time upon the same farm:

Alfalfa	5,113 lbs.	Oat	39.6 bush.
Barley	27.5 bush.	Onion	60,746 lbs.
Bean	22 bush.	Pea	16.5 bush.
Beet	20,800 lbs.	Potato	6,860 lbs.
Cabbage	27,333 lbs.	Rye	19 bush.
Carrot	42,816 lbs.	Sugar beet	16,330 lbs.
Corn	23 bush.	Turnip	10,725 lbs.
Flax	9 bush.	Wheat	26.3 bush.

During the three years, this farm excelled the other four in producing the best crops of beans and onions, and was second in alfalfa, beets, cabbage and corn. It also ranked first in the average yield of beans and onions.

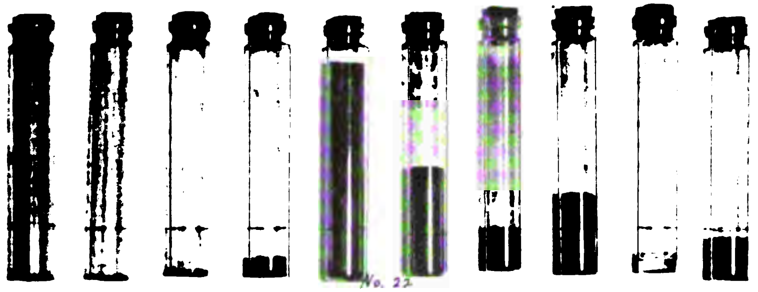
AGRICULTURAL SOILS OF WYOMING.

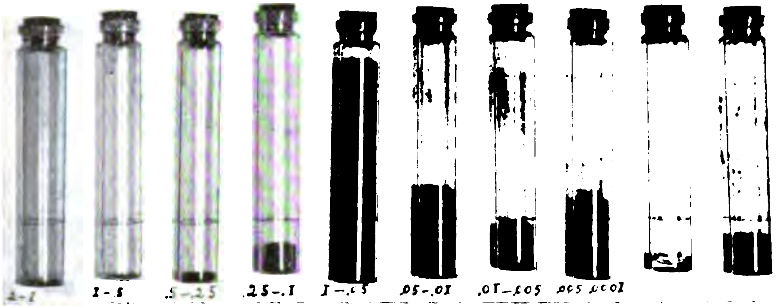
LANDER EXPERIMENT FARM.

No. 21.

Per cent. of Gravel, Sand, Silt, Clay, Organic Matter and Water in 20 Grams of Soil and Subsoil.

Gravel	Coarse Sand	Medium Sand	Fine Sand	Very fine Sand	Silt	Fine Silt	Clay	Water	Organic Matter
0.140	0.150	0.525	3.390	56.495	18.330	5.495	9915	1.940	3.260
0.125	0.165	1.005	4.795	58.070	17100	5.295	8.895	1320	2.720
2-1 mm.	1-.5 mm.	.5-.25 mm.	.25-.1 mm.	1-.05 mm.	.05-.01 mm.	.01-.005 mm.	.005 .0001 mm.	mm.	mm.





Diameter of Grains in Millimeter.

Soil from the Sundance Experiment Farm.

This farm is located in the northeastern part of the state, at an elevation of 4,750 feet above the sea level. The soil of the farm has been formed from the Triassic and Jurassic rocks, which are composed of ferruginous sandstone, limestone, clays, and marls. The soil has not been transported any great distance, and in composition and color greatly resembles that of the Lander farm.*

On the prairie sod, where samples 7 and 8 were taken, were found growing blue stem (*Agropyron* sp.), with an occasional bunch of gramma grass (*Bouteloua oligostachya*, Torr). The soil was very dry to a depth of 14 inches and changes color from a dark to a light red. From 14 inches down to a depth of at least three feet the soil was damp and easy to dig. In taking samples 9 and 10, there was found at a depth of 20 inches a layer of black soil. Considerable difficulty was experienced in digging these samples on account of the exceedingly dry condition of ground. The plat from which these samples were taken had not been irrigated during the season, which accounts for the very dry condition of the soil. The soil from which samples 11 and 12 were taken was found to be very loose and friable, containing many pieces of soft sandstone at a depth of about 9 inches. A bed of loose sand was found at a depth of two feet, which appeared to be arranged in streaks throughout the soil, of a very fine texture and of a red color. As the depth increased, the soil became more moist. There were very few lumps found in this soil and they were very easily crushed by the fingers. On moistening these lumps with water, it was found that they absorbed moisture very quickly and became quite plastic. A few small pebbles were found, but constituted less than .1 per cent of the soil. These pebbles were of limestone, granite, lime incrustations on granite, quartz, sandstone, and shale.

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*See Bulletin No. 14, page 114.

The following results were obtained from a mechanical analysis of these soils:

No. of Sample		Locality	Gravel (2-1 mm.)	Coarse sand (1-.5 mm.)	Medium sand (.5-.25 mm.)	Fine sand (.25-.1 mm.)	Very fine sand (.1-.05 mm.)	Silt (.05-.01 mm.)	Fine silt (.01-.005 mm.)	Clay (.005-.0001 mm.)	Moisture in air-dried sample	Organic and volatile matter	Loss
Top soil (0-12 in.)	Subsoil (12-24 in.)												
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
7		Sundance	0.005	0.045	0.070	0.640	64.005	10.735	1.885	14.000	2.020	4.180	2.415
	8	"	0.005	0.040	0.070	0.745	60.775	14.765	2.545	13.300	2.080	3.480	2.195
9		"	0.000	0.000	0.005	0.065	38.875	32.350	4.105	13.350	2.440	4.880	3.930
	10	"	0.000	0.000	0.015	0.365	38.500	30.995	7.465	15.150	2.040	4.960	0.510
11		"	0.565	0.375	1.670	3.975	54.025	12.420	4.730	14.400	1.280	4.980	0.680
	12	"	0.470	0.495	2.985	5.815	51.900	24.365	1.420	8.390	1.460	2.520	0.180
		Average	0.174	0.159	0.803	1.934	51.497	20.938	3.691	13.097	1.887	4.167	

The greatest yield of crops per acre upon this farm during three years is shown below.

Barley	53 bush.	Parsnip	2,728 lbs.
Bean	9 bush.	Pea	23.3 bush.
Beet	24,888 lbs.	Potato	18,810 lbs.
Cabbage	4,900 lbs.	Rye	22.5 bush.
Carrot	14,014 lbs.	Salsify	4,590 lbs.
Corn	50 bush.	Sugar beet	13,167 lbs.
Flax	5.5 bush.	Timothy hay	2,800 lbs.
Garlic	3,128 lbs.	Turnip	16,744 lbs.
Oat	62 bush.	Wheat	40 bush.
Onion	32,640 lbs.		

The following are the average yields per acre for three years upon the same farm:

Barley	33.5 bush.	Onion	13,192 lbs.
Bean	5 bush.	Pea	20 bush.
Beet	14,123 lbs.	Potato	6,730 lbs.
Cabbage	4,200 lbs.	Rye	11 bush.
Carrot	7,336 lbs.	Sugar beet	7,774 lbs.
Corn	39 bush.	Turnip	15,400 lbs.
Flax	5 bush.	Wheat	27.5 bush.
Oat	29 bush.		

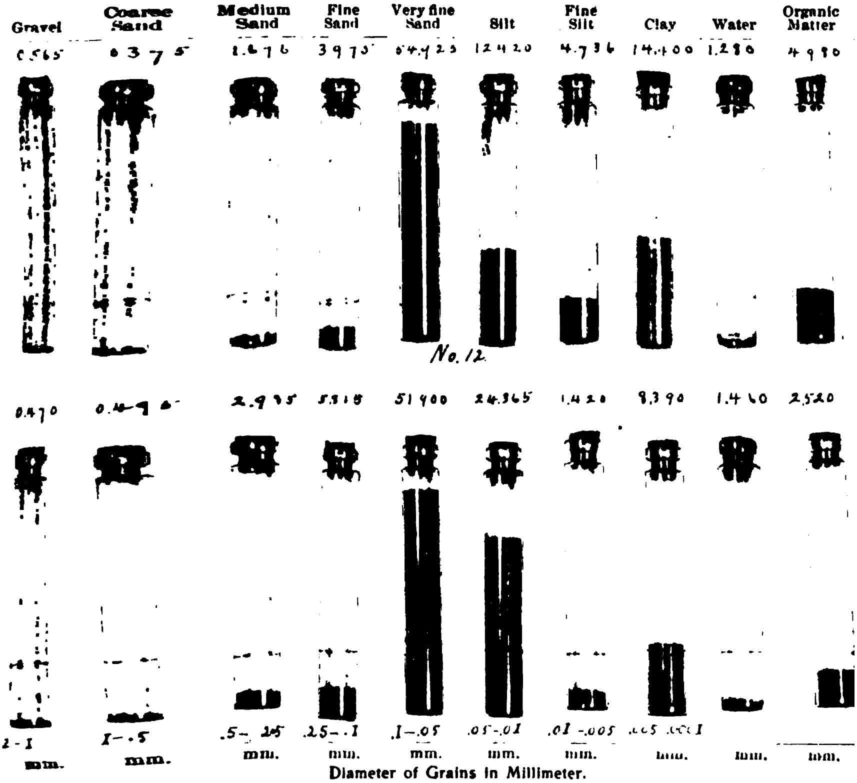
We find that this farm stands first in producing the greatest yield of corn, and second in barley. It also ranks first in the average yield of these two crops.

AGRICULTURAL SOILS OF WYOMING.

SUNDANCE EXPERIMENT FARM.

No. 11.

Per cent. of Gravel, Sand, Silt, Clay, Organic Matter and Water in 20 Grams of Soil and Subsoil.



Diameter of Grains in Millimeter.

Soil from the Sheridan Experiment Farm.

The Sheridan farm is situated in the northern part of Wyoming, in the Tongue River valley, at an elevation of 3,750 feet. The underlying rock is of the Laramie group (Cretaceous), but the soil is alluvial, derived principally from Paleozoic and Mesozoic rocks.*

The native sod is blue stem (*Agropyron* sp.), porcupine grass (*Stipa comata* Trin.) and *Koeleria cristata* Pers. Around a stack of hay on the plat were found growing sweet clover (*Melilotus alba* Lam.), prairie clover (*Kuhnistera* sp.), sage-brush (*Artemisia tridentata* Nutt), gum plant (*Grindelia squarrosa* Dunal.), and lupine (*Lupinus* sp.)

In taking samples 13 and 14 the soil appeared to be about the same to the depth of three feet, becoming more moist, however, as the depth increased, and also a little darker in color. The top soil was dry but very friable. The soil of samples 15 and 16 was very dark, with the exception of five or six inches of the top soil, which was rather light in color. The ground was found to be moist and soft to a depth of at least two feet. This plat had been irrigated on July 17,and samples were taken August 15. The next top soil (sample 17) was soft, moist, and dark in color. At a depth of 19 inches occurred a streak of red soil which was very difficult to dig through. There were a few pebbles found scattered throughout the soil of this farm, consisting of granite, quartz, limestone, jasper, mica schist, oxide of iron concretions, and sandstone. The pebbles found constituted less than .1 per cent of the soil. The lumps found in the air-dry samples were so very hard that it was almost impossible to crush some of them with the rolling-pin. After being moistened with water, the hard lumps softened very quickly and the soil became plastic.

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*See Bulletin No. 14, page 112.

The following results were obtained from a mechanical analysis of these samples:

No. of Sample: Top soil (0-12 in.)	No. of Sample: Subsoil (12-24 in.)	Locality	Gravel (2-1 mm.)	Coarse sand (1-.5 mm.)	Medium sand (.5-.25 mm.)	Fine sand (.25-.1 mm.)	Very fine sand (.1-.05 mm.)	Silt (.05-.01 mm.)	Fine silt (.01-.005 mm.)	Clay (.005-.0001 mm.)	Moisture in air-dried sample	Organic and volatile matter	Loss
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
13		Sheridan	0.310	0.695	11.325	36.820	19.850	4.495	1.210	19.425	1.860	2.860	1.150
	14	"	0.355	0,745	13.960	37.910	17.195	3.480	1.175	18.495	2.440	2.540	1.705
15		"	0.105	0.585	10.395	36.160	18.170	5.590	1.950	19.705	2.720	3.660	0.960
	16	"	0.290	0.755	11.770	34.700	16.335	5.140	1.680	21.355	2.900	3.520	1.555
17		"	0.195	0.200	8.685	30.565	22.700	8.205	2.360	19.900	2.380	4.800	0.610
	18	"	0.100	0.420	7.860	29.875	19.930	7.505	3.075	22.865	3.060	4.400	0.910
		Average	0.226	0.567	10.566	34.339	19.030	5.735	1.905	20.289	2.560	3.630	

The greatest yield of crops per acre during three years upon this farm is shown below.

Alfalfa	16,800 lbs.	Onion	20,294 lbs.
Barley	41.6 bush.	Pea	15.1 bush.
Bean	21.6 bush.	Potato	20,010 lbs.
Beet	17,640 lbs.	Rye	83 bush.
Buckwheat	26 bush.	Sunflower	30 bush.
Carrot	97,440 lbs.	Sugar beet	40,400 lbs.
Corn	40 bush.	Timothy hay and clover	7,200 lbs.
Flax	20.6 bush.		
Lentil	9 bush.	Turnip	48,050 lbs.
Oat	80 bush.	Wheat	54.5 bush.

The following are the average yields per acre upon the same farm for the same period of three years:

Alfalfa	13,700 lbs.	Onion	17,806 lbs.
Barley	33 bush.	Pea	15.1 bush.
Bean	11.5 bush.	Potato	12,145 lbs.
Beet	13,228 lbs.	Rye	17.6 bush.
Carrot	56,100 lbs.	Sugar beet	24,022 lbs.
Corn	24 bush.	Turnip	44,990 lbs.
Flax	11 bush.	Wheat	31 bush.
Oat	49.1 bush.		

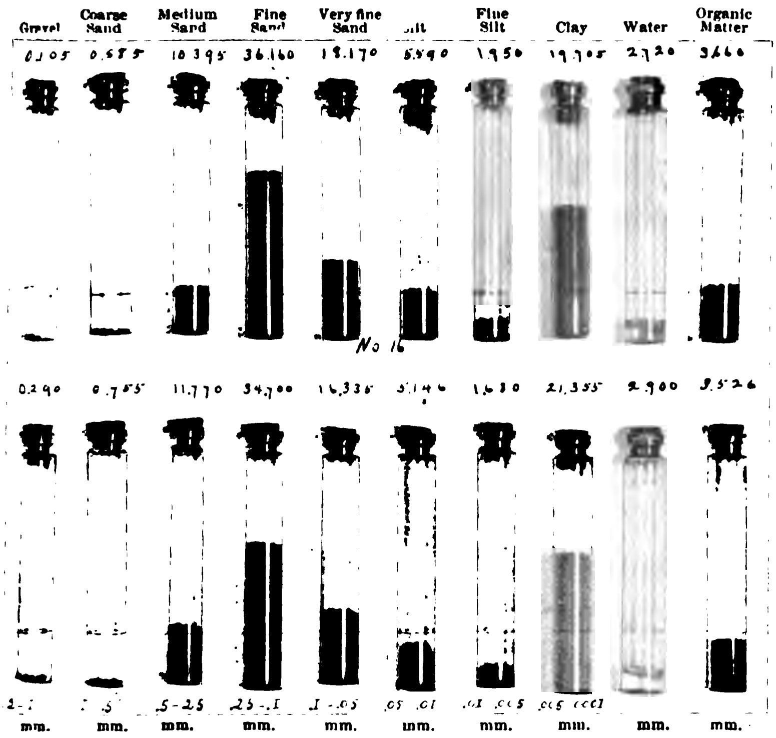
This farm was first in producing the greatest yield of alfalfa, carrots, flax, and rye, and second in raising turnips, beans, and wheat. In the average yield it stood first as a producer of carrots and oats.

AGRICULTURAL SOILS OF WYOMING.

SHERIDAN EXPERIMENT FARM.

No. 15.

Per cent. of Gravel, Sand, Silt, Clay, Organic Matter and Water in 20 Grams of Soil and Subsoil.



Diameter of Grains in Millimeter

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Soil from the Lander Experiment Farm.

The Lander Experiment Farm is located in the central part of the state, in the Popo Agie River valley, at an altitude of 5,500 feet. The soil of one part of the farm is formed of decomposed red sandstone and clay, while another part is a mixture of decomposed marble and sandstone. The soil covers the Lower Triassic rocks, and most of the material entering into the composition of the soil came from the same formation.*

Samples 19 and 20 were taken from the prairie sod, upon which were growing blue stem (*Agropyron* sp.), coarse-leaved sage (*Artemisia* sp.), milk weed (*Asclepias* sp.), and rabbit-brush (*Chrysothamnus frigidus* Greene). The top soil was of a dark red color, moist to a depth of 10 inches below the surface, where it became dry, lighter in color and hard to dig. At a depth of 15 inches a streak of gravel three inches thick was found; beneath this gravel bed the soil appeared to be of red clay, quite soft and easy to dig. Samples 21, 22, 23, and 24 appeared to be of the same nature as 19 and 20, and occurring under similar conditions. The lumps found in the air-dried soil were very difficult to crush but absorbed water quickly and became quite friable.

The following results were obtained from a mechanical analysis of these samples:

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*See Bulletin No. 14, page 108.

No. of Sample		Locality	Gravel (2–1 mm.)	Coarse sand (1–.5 mm.)	Medium sand (.5–.25 mm.)	Fine sand (.25–.1 mm.)	Very fine sand (.1–.05 mm.)	Silt (.05–.01 mm.)	Fine silt (.01–.005 mm.)	Clay (.005–.0001 mm.)	Moisture in air-dried sample	Organic and volatile matter	Loss
Top soil (0–12 in.)	Subsoil (12–21 in.)		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
19		Lander. .	0.245	0.180	0.725	4.270	64.245	9.620	1.715	12.635	1.860	3.180	1.325
	20	"	0.595	0.630	1.475	5.035	60.045	20.805	0.850	5.510	1.440	2.500	1.115
21		"	0.140	0.150	0.525	3.390	56.495	18.330	5.495	9.915	1.940	3.260	0.300
	22	"	0.125	0.165	1.055	4.795	58.070	17.100	5.295	8.895	1.320	2.720	0.460
23		"	0.080	0.085	0.090	1.725	47.885	15.060	6.765	21.625	2.440	3.560	0.665
	24	"	0.130	0.080	0.160	1.475	41.930	19.065	8.685	21.625	1.800	4.020	1 030
		Average	0.219	0.215	0.671	3.448	54.745	16.663	4.434	13.367	1.800	3.207	

The greatest yield of crops per acre during three years upon this farm is shown below.

Alfalfa	8,000 lbs.	Lettuce	5,672 lbs.
Barley	12 bush.	Oat	60 bush.
Bean	16 bush.	Onion	20,869.3 lbs.
Beet	62,627 lbs.	Pea	45.5 bush.
Cabbage	62,954 lbs.	Potato	40,933 lbs.
Cauliflower	11,904 lbs.	Radish	3,373 lbs.
Carrot	40,671 lbs.	Rye	44.5 bush.
Corn	23.4 bush.	Sugar beet	62,627 lbs.
Flax	16.1 bush.	Turnip	38,928 lbs.
Lentil	2,730 lbs.	Wheat	35 bush.

The following are the average yields per acre upon the same farm for the same period:

Alfalfa	3,500 lbs.	Oat	33 bush.
Barley	10.5 bush.	Onion	14,529.7 lbs.
Bean	12.6 bush.	Pea	33.3 bush.
Beet	30,644.6 lbs.	Potato	16,303 lbs.
Cabbage	59,157.9 lbs.	Rye	19.6 bush.
Carrot	28,772 lbs.	Sugar beet	44,357 lbs.
Corn	19.75 bush.	Turnip	34,715 lbs.
Flax	16.1 bush.	Wheat	20 bush.

This farm produced the greatest yield of beets, cabbage, peas, potatoes, and sugar beets, and was second in raising the most onions and rye. In the average yield it stood first as a producer of beets, cabbage, peas, potatoes, rye, and sugar beets.

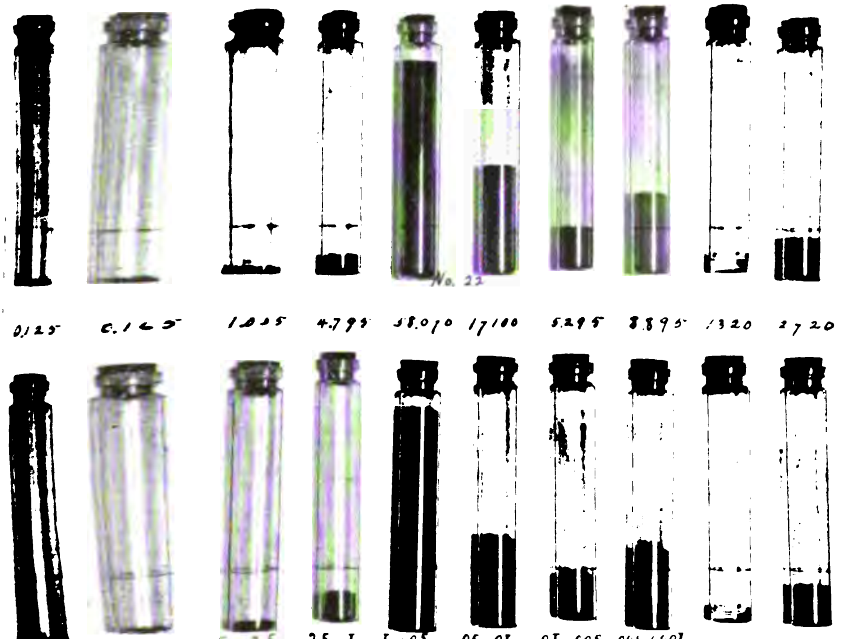
AGRICULTURAL SOILS OF WYOMING.

LANDER EXPERIMENT FARM.

No. 21.

Per cent. of Gravel, Sand, Silt, Clay, Organic Matter and Water in 20 Grams of Soil and Subsoil.

Gravel	Coarse Sand	Medium Sand	Fine Sand	Very fine Sand	Silt	Fine Silt	Clay	Water	Organic Matter
0.140	0 150	0.525	3.390	56495	18.330	5.495	9915	1940	3.260
0.125	0.165	1.035	4.795	58.010	17100	5.295	8.895	1320	2720
2-1 mm.	1-5 mm.	.5-.25 mm.	.25-.1 mm.	.1-.05 mm.	.05-.01 mm.	.01-.005 mm.	.005-.001 mm.	mm.	mm.



Diameter of Grains in Millimeter.

Soil from the Laramie Experiment Farm.

The Experiment Farm is situated in the southeastern part of the state at an altitude of 7,200 feet. The soil covers the Cretaceous sandstone and is composed of Archaean, Mesozoic,and Paleozoic rocks.* Well-worn pebbles of schist, gneiss, quartz, orthoclase, and granite were found which composed about 11 per cent of the soil.

Samples 25 and 26 were taken from the prairie sod, which was very dry and quite difficult to dig the first foot. As the depth increased the soil became more moist and much less difficult to dig till the depth of two feet was reached, when a hard pan was struck which was about two inches thick and quite difficult to penetrate with the spade. Samples 27 and 28 were taken from soil which had been cultivated, and which was found to be quite moist at the time of digging the samples. Samples 29 and 30 were taken from a plat which had been abandoned on account of the great quantity of alkali contained in the soil. The earth was found to be very moist to a depth of three feet. The lumps found in the air-dried samples 25 and 26 were very hard to crush, but those from 27, 28, 29, and 30 crumbled very readily. The lumps absorbed moisture quickly and became quite plastic. The soil was of a light gray color and became very light at the depth of three feet.

The mechanical analysis gave the following results:

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*See Bulletin No. 14, page 105

No. of Sample Top soil (0-12 in.)	No. of Sample Subsoil (12-24 in.)	Locality	Gravel (2-1 mm.)	Coarse sand (1-.5 mm.)	Medium sand (.5-.25 mm.)	Fine sand (.25-.1 mm.)	Very fine sand (.1-.05 mm.)	Silt (.05-.01 mm.)	Fine silt (.01-.005 mm.)	Clay (.005-.0001 mm.)	Moisture in air-dried sample	Organic and volatile matter	Loss
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
25		Laramie .	3.390	3.030	7.405	16.295	32.075	8.390	3.440	19.285	3.260	3.060	0.370
	26	"	8.950	4.045	6.890	11.780	21.175	5.770	2.870	30.530	2.360	2.600	3.030
27		"	5.570	5.070	10.060	19.880	34.915	2.900	1.585	14.040	1.640	2.180	2.160
	28	"	5.655	3.640	7.200	15.575	24.725	4.750	4.205	28.300	2.740	2.440	0.770
29		"	8.280	4.335	8.515	16.785	33.450	5.065	1.505	16.750	1.920	2.900	0.495
	30	"	2.890	2.650	6.500	15.140	27.715	5.490	3.915	29.005	2.940	3.040	0.655
		Average	5.789	3.795	7.772	5.909	29.009	5.394	2.920	22.985	2.477	2.703	

The greatest yield of crops per acre during three years upon this farm is shown below.

Alfalfa	6,030.4 lbs.	Oat	109.5 bush.
Barley	94.1 bush.	Onion	48,094 lbs.
Beet	27,514 lbs.	Parsley	21,251 lbs.
Cabbage	16,151 lbs.	Pea	24.9 bush.
Cauliflower	2,588 lbs.	Potato	32,988 lbs.
Carrot	21,107 lbs.	Rape	29,180 lbs.
Flat pea	3,416 lbs.	Radish	36,028 lbs.
Flax	18.4 bush.	Rye	34.3 bush.
Garlic	4,309 lbs.	Spinach	46,827 lbs.
Kahlrabi	15,475 lbs.	Sugar beet	56,784 lbs.
Leek	28,189 lbs.	Turnip	68,244 lbs.
Lettuce	60,984 lbs.	Wheat	78.7 bush.

The following are the average yields per acre upon the same farm for the same period:

Alfalfa	3,106 lbs.	Onion	37,930 lbs.
Barley	33.1 bush.	Pea	17.5 bush.
Beet	16,413 lbs.	Potato	11,713 lbs.
Cabbage	3,973 lbs.	Rye	14.2 bush.
Carrot	13,583 lbs.	Sugar beet	18,149.8 lbs.
Flax	15.6 bush.	Turnip	20,173.8 lbs.
Oat	42.8 bush.	Wheat	29.3 bush.

This farm excelled all the others in producing the greatest amount of barley, turnips, and wheat, and was second in the production of flax, peas, potatoes, and sugar beets. In the average yield, it stood first in raising flax.

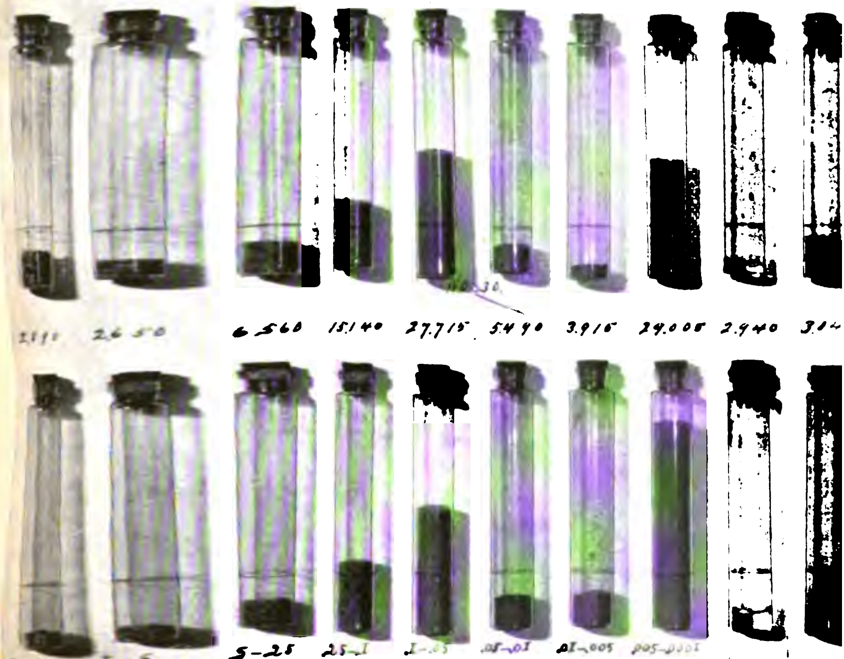
AGRICULTURAL SOILS OF WYOMING.

LARAMIE EXPERIMENT FARM.

No. 29.

Per cent. of Gravel, Sand, Silt, Clay, Organic Matter and Water in 20 Grams of Soil and Subso

Gravel	Coarse Sand	Medium Sand	Fine Sand	Very fine Sand	Silt	Fine Silt	Clay	Water	Organ Matte
1.280	4.335	8.515	16.785	33.450	5.165	1.505	16.750	1.920	2.90
2.11	2.650	6.560	15.140	27.715	5.490	3.915	24.005	2.940	3.1
2-1 mm.	1-.5 mm.	.5-.25 mm.	.25-.1 mm.	.1-.05 mm.	.05-.01 mm.	.01-.005 mm	.005-.0001 mm.	mm.	mm.



Diameter of Grains in Millimeter.

Greatest Yield per Acre on Each of the Five Experiment Farms During Three Years.

CROP.	WHEATLAND	SUNDANCE.	SHERIDAN	LANDER	LARAMIE
Alfalfa	8,732 lbs.	. . . .	16,800 lbs.	8,000 lbs.	6,030.4 lbs.
Barley	50 bush.	53 bush.	41.6 bush.	12 bush.	94.1 bush.
Bean	26 bush.	9 bush.	21.6 bush.	16 bush.	. . . .
Beet	43,776 lbs.	24,888 lbs.	17,640 lbs.	62,627 lbs.	27,514.7 lbs.
Cabbage	34,362 lbs.	4,900 lbs.	. . . .	62,954.2 lbs.	16,151.1 lbs.
Carrot	75,240 lbs.	14,014 lbs.	97,440 lbs.	40,671.3 lbs.	21,107.2 lbs.
Corn.	48 bush.	50 bush.	40 bush.	23.4 bush.	. . . .
Flax.	14 bush.	5.5 bush.	20.6 bush.	16.1 bush.	18.4 bush.
Oat	74.2 bush.	62 bush.	80 bush.	60 bush.	109.5 bush.
Onion.	93,492 lbs.	32,640 lbs.	20,294 lbs.	20,869.3 lbs.	48,094 lbs.
Pea	17 bush.	23.3 bush.	15.1 bush.	45.5 bush.	24.9 bush.
Potato.	25,740 lbs.	18,810 lbs.	20,010 lbs.	40,932 lbs.	32,988 lbs.
Rye.	31 bush.	22.5 bush.	83 bush.	44.5 bush.	34.3 bush.
Sugar Beet	24,000 lbs.	13,167 lbs.	40,400 lbs.	62,627.5 lbs.	56,784 lbs.
Turnip.	12,869 lbs.	16,744 lbs.	48,060 lbs.	38,928.3 lbs.	68,244.6 lbs.
Wheat	50 bush.	40 bush.	54.5 bush.	35 bush.	78.7 bush.

Greatest Average Yield per Acre on Each of the Five Experiment Farms During Three Years.

CROP.	WHEATLAND	SUNDANCE	SHERIDAN	LANDER	LARAMIE
Alfalfa	5,113 lbs.	. . . .	13,700 lbs	3,500 lbs.	3,106.4 lbs.
Barley	27.5 bush.	33.5 bush.	33 bush.	10.5 bush.	33.1 bush.
Bean	22 bush.	5 bush.	11.5 bush.	12.6 bush.	. . . .
Beet	20,800 lbs.	14,123 lbs.	13,228 lbs.	30.646.6 lbs.	16,413.6 lbs.
Cabbage	27,333 lbs.	4,200 lbs.	. . . .	59,157 lbs.	3,973.6 lbs.
Carrot	42,816 lbs.	7,336 lbs.	56,100 lbs.	28,772 lbs.	13,583 lbs.
Corn.	23 bush.	39 bush.	24 bush.	19.75 bush.	. . . .
Flax.	9 bush.	5 bush.	11 bush	16.1 bush.	15.6 bush.
Oat	39.6 bush.	20 bush.	49.1 bush.	33 bush.	42.8 bush.
Onion	60,746 lbs.	13,192 lbs.	17,806 lbs.	14,529.7 lbs.	37,930 lbs.
Pea	16.5 bush.	20 bush.	15.1 bush.	33.3 bush.	17.5 bush.
Potato.	6,860 lbs.	6,730 lbs.	12,145 lbs.	16,303 lbs.	11,713 lbs.
Rye	19 bush.	11 bush.	17.6 bush.	19.6 bush.	14.2 bush.
Sugar Beet	16,330 lbs.	7,774 lbs.	24,022 lbs.	44,357 lbs.	18,149.8 lbs.
Turnip	10,725 lbs.	15,400 lbs.	44,990 lbs.	34,715 lbs.	20,173.8 lbs.
Wheat	26.3 bush.	27.5 bush.	31 bush.	20 bush.	29.3 bush.

Chemical Analysis of Wyoming Soils.

The soils of the Wyoming Experiment Farms were analyzed by E. E. Slosson, Chemist of the Station, in 1892, before they had been cultivated, and the analyses were published in Bulletin No. 6. As that bulletin is out of print, averages of the analyses of the surface and subsoil of each farm are here republished.

WHEATLAND EXPERIMENT FARM.

Analysis of fine earth.	Surface 1-9 in.	Subsoil 9-18 in.
Insoluble matter	77.92	72.18
Soluble silica	3.52	1.36
Potash (K_2O)	.63	.41
Soda (Na_2O)	.34	.34
Lime (CaO)	.87	5.29
Magnesia (MgO)	.85	1.29
Iron (Fe_2O_3)	3.52	2.94
Alumina (Al_2O_3)	6.88	5.09
Phosphoric acid (P_2O_5)	.14	.15
Sulphuric acid (SO_3)	.08	.08
Carbonic acid (CO_2)	.88	5.39
Moisture	1.62	1.80
Volatile and combustible matter	3.62	3.04
	100.87	99.36
Soluble in water	.1726	.0427
Chlorine	.007	.0007

SUNDANCE EXPERIMENT FARM.

Analysis of fine earth.	Surface 1-9 in.	Subsoil 9-18 in.
Insoluble matter	68.39	75.27
Soluble silica	.98	1.87
Potash (K_2O)	.68	.53
Soda (Na_2O)	.90	.30
Lime (CaO)	4.97	2.30
Magnesia (MgO)	3.21	2.12
Iron (Fe_2O_3)	3.40	3.17
Alumina (Al_2O_3)	5.42	5.86
Phosphoric acid (P_2O_5)	.18	.19
Sulphuric Acid (SO_3)	.18	.18
Carbonic acid (CO_2)	6.53	1.68
Moisture	1.88	1.88
Volatile and combustible matter	3.60	4.36
	100.32	99.71
Soluble in water	.0505	.0777
Chlorine	.0003	.0014

SHERIDAN EXPERIMENT FARM.

Analysis of fine earth.	Surface 1-9 in.	Subsoil 9-18 in.
Insoluble matter	81.72	71.74
Soluble silica	1.57	1.59
Potash (K_2O)	.52	.59
Soda (Na_2O)	.20	.34
Lime (CaO)	.69	1.19
Magnesia (MgO)	.94	2.26
Iron (Fe_2O_3)	2.98	4.09
Alumina (Al_2O_3)	5.83	8.75
Phosphoric acid (P_2O_5)	.28	.23
Sulphuric acid (SO_3)	.14	.24
Carbonic acid (CO_2)		.59
Moisture	1.73	3.23
Volatile and combustible matter	3.81	4.92
	100.41	99.76
Soluble in water	.0498	.2701
Chlorine	.0008	.0014

LANDER EXPERIMENT FARM.

Analysis of fine earth.	Surface 1-9 in.	Subsoil 9-18 in.
Insoluble matter	74.66	70.31
Soluble silica	2.08	2.43
Potash (K_2O)	.64	.67
Soda (Na_2O)	.24	.35
Lime (CaO)	3.64	6.46
Magnesia (MgO)	1.51	1.62
Iron (Fe_2O_3)	2.48.	3.05
Alumina (Al_2O_3)	3 69	4 60
Phosphoric acid (P_2O_5)	.17	.18
Sulphuric acid (CO_3)	.10	.08
Carbonic acid (CO_2)	2.39	4.29
Moisture	1.78	1.57
Volatile and combustible matter	6.22	3.92
	99.60	99.53
Soluble in water	.2599	.1110
Chlorine	.0505	.0038

LARAMIE EXPERIMENT FARM.

Analysis of fine earth.	Surface 1-9 in.	Subsoil 9-18 in.
Insoluble matter	80.11	77.28
Soluble silica	2.78	1.92
Potash (K_2O)	.60	.53
Soda (Na_2O)	.65	.45
Lime (CaO)	1.14	3.77
Magnesia (MgO)	.45	.08
Iron (Fe_2O_3)	2.79	2.49
Alumina (Al_2O_3)	4.95	4.71
Phosphoric acid (P_2O_5)	.14	.15
Sulphuric acid (SO_3)		.07
Carbonic acid (CO_2)	.69	3.70
Moisture	1.87	1.24
Volatile and combustible matter	3.21	2.82
	99.38	99.21
Soluble in water	.0829	.0464
Chlorine	.001	.001

Professor Hilgard, of the University of California, has this to say in regard to the amount of lime, phosphoric acid, and potash necessary to give a soil lasting fertility:

"The *lime* percentage should not fall below 0.1 per cent in thelightest sandy soils; in clay loams not below 0.25 per cent, and in heavy clay soils not below 0.5 per cent; and it may advantageously rise to 1 and even 2 per cent as a maximum. Beyond the latter figure it seems in no case to act more favorably than a less amount, unless it be mechanically.

"The percentage of *phosphoric acid* is that which, in connection with the lime, seems to govern most commonly the productiveness of our virgin soils. In any of these, less than .05 must be regarded as a serious deficiency, unless accompanied by a large amount of lime. In sandy loams, 0.1 per cent, when accompanied by a fair supply of lime, secures fair productiveness for from eight to fifteen years; with a deficiency of lime, twice that percentage would only serve for a similar time.

"The *potash* percentages of soils seem, in a large number of cases, to vary with that of 'clay;' that is, in clay soils they are usually high, in sandy soils low; and since subsoils are in all ordinary cases more clayey than surface soils, their potash percentages are almost invariably higher.

"The potash percentage of heavy clay upland soil, and clay loams, ranges from about 0.8 to 0.5 per cent; lighter loams from 0.45 to 0. 30 per cent; sandy loams below 0.3 per cent, and sandy soils of great depth may fall below 0.1 per cent consistently with good productiveness and durability. Virgin soils falling below 0.6 per cent in potash seem in most cases to be deficient in available potash, its application to such soils being followed by an immediate great increase of production. Sometimes, however, a soil very rich in lime and phosphoric acid, shows good productiveness, despite a very low potash percentage, and conversely, a high potash percentage seems capable of offsetting a low one of lime."

From the chemical analyses of the soils of the five Experiment Farms, as shown by the preceding tables, we find these soils to contain the following percentages of lime, phosphoric acid, and potash:

		Lime.	Phosphoric acid	Potash
Wheatland	Soil	.87	.14	.63
	Subsoil	5.29	.15	.41
Sundance	Soil	4.97	.18	.68
	Subsoil	2.30	.19	.53
Sheridan	Soil	.69	.28	.52
	Subsoil	1.19	.23	.59
Lander	Soil	3.64	.17	.64
	Subsoil	6.46	.18	.67
Laramie	Soil	1.14	.14	.60
	Subsoil	3.77	.15	.53

From this we conclude that the soils of Wyoming will last at least for some years with continual tillage, and without the necessity of resorting to artificial fertilizers.

In Bulletin No. 5, U. S. Department of Agriculture, Division of Agricultural Soils, are to be found the results of the mechanical analysis of some typical truck, wheat, and grass lands. The typical truck land was found at Marley, Md., the typical wheat land at Davidsonville, Md., and the typical grass land at Hagerstown, Md.

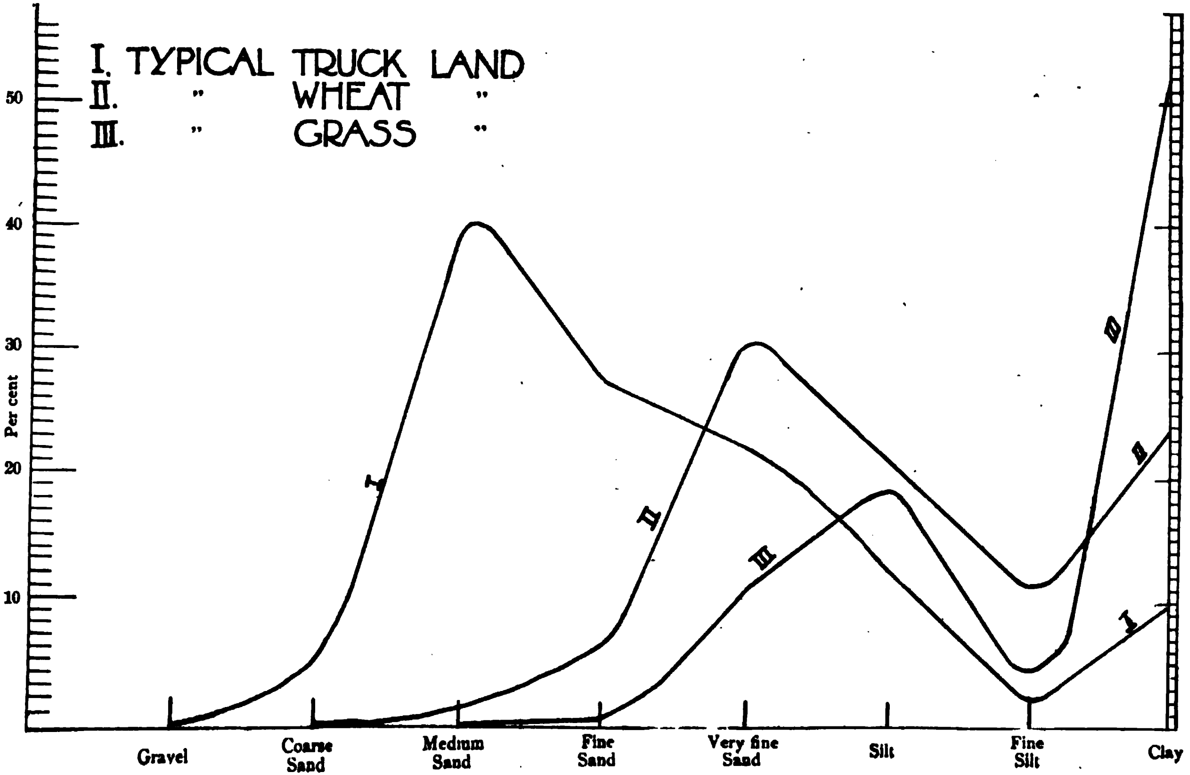
The following table shows the per cent of grains of various texture entering into the composition of these soils, and immediately following, for the sake of comparison, is a similar table of the soils of Wyoming.

	Truck.	Wheat.	Grass.
Gravel	0.49	0.00	0.00
Coarse sand	4.96	0.23	0.08
Medium sand	40.19	1.71	0.13
Fine sand	27.59	6.08	0.53
Very fine sand	12.1	30.82	10.94
Silt	7.74	20.92	19.02
Fine silt	2.23	11.21	4.67
Clay	4.4	23.78	51.75

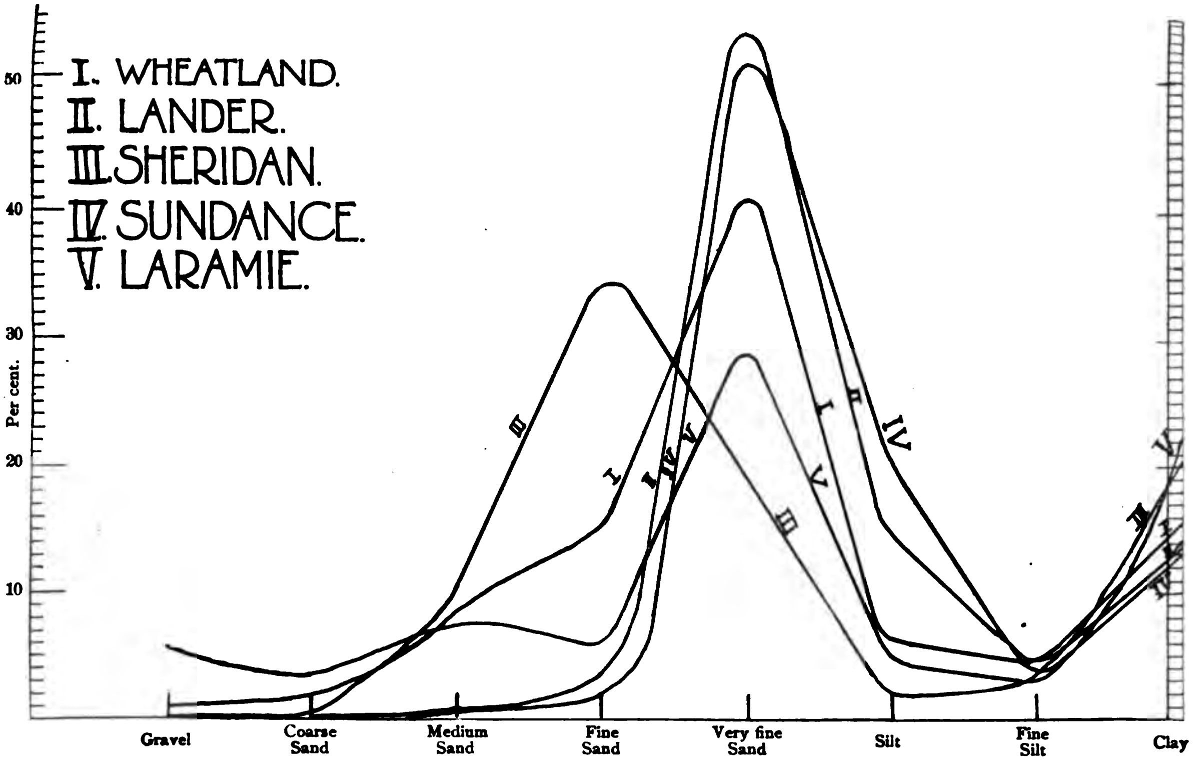
	Wheatland	Sundance	Sheridan	Lander	Laramie
Gravel	1.06	0.17	0.22	0.21	5.78
Coarse sand	1.85	0.15	0.56	0.21	3.79
Medium sand	8.60	0.80	10.56	0.67	7.77
Fine sand	15.09	1.93	34.33	3.44	5.90
Very fine sand	40.16	51.49	19.03	54.74	29.00
Silt	6.18	20.93	5.73	16.66	5.39
Fine silt	4.33	3.69	1.90	4.43	2.92
Clay	15.19	13.09	20.28	13.36	22.98

From these tables, and especially from the charts which immediately follow, one can readily see that none of the soils of Wyoming resemble the typical soils of the Atlantic Coast States very closely.

On the charts, the curves, which might be termed "soil-texture curves," have for abscissas the different sized grains, and for ordinates the per cent of the different sized grains composing the soil. The soils from Lander and Sundance are very similar, while those from Laramie, Wheatland, Lander, and Sundance resemble one another in that they all contain more very fine sand than of any other quality. The soils from these four farms resemble the typical wheat land of the east more than they resemble either the truck or grass land. The soil of the Sheridan farm is more like the typical truck land; and yet this farm produced a better crop of alfalfa than any of the other four.



SOIL-TEXTURE CURVES.



SOIL-TEXTURE CURVES.

DETERMINATION OF MOISTURE

. . . IN THE . . .

Soil of the Laramie Experiment Farm

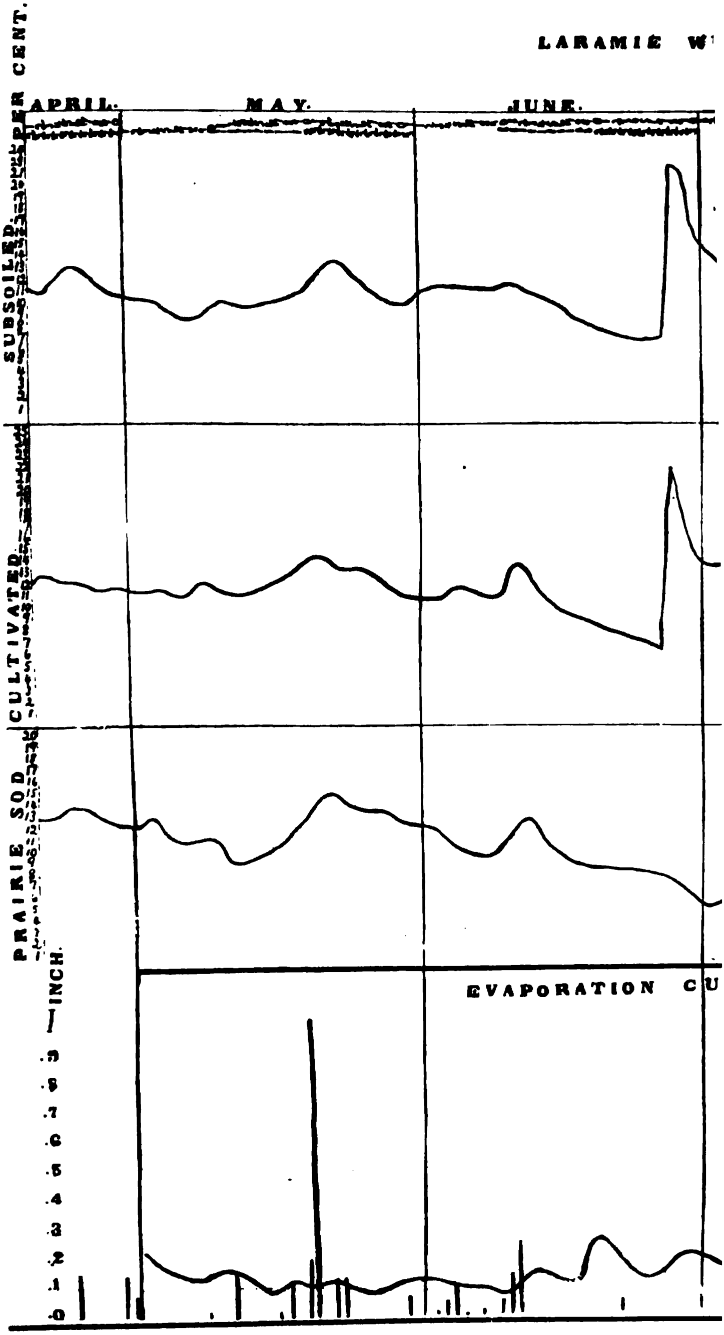
FOR THE YEAR 1897.

The work of taking samples of soil was begun on April 20, 1897, and continued without intermission till the first of September of the same year. The samples were taken with brass tubes about ⅞ inch in internal diameter and 16 inches long. In one end of the tube a brass collar had been securely fastened, and this end then turned down on a lathe till it tapered in as far as the collar. The object of the collar was to cut a core of earth as the tube was driven into the soil with a wooden mallet to the depth of 12 inches. The tube with its contents was carefully withdrawn from the earth and each end closed with a rubber stopper to prevent any evaporation of moisture. The samples, which were taken each day at 5:30 p. m., were carefully weighed in aluminum dishes, placed in a drying oven for 24 hours and kept at a constant temperature of 93°C., (the temperature at which water boils in this altitude).

Three plats, each 25 feet square, were chosen from which to take soil. Stakes were driven at the corners of the plats and ropes stretched around to prevent trespassing. Plat No. 1 was on the prairie sod, upon which were growing buffalo grass (*Bulbilis dactyloides*) and blue stem (*Agropyron* sp.) Plat No. 2 was on ground which had been plowed and harrowed but not subsoiled. In Plat No. 3 the soil had been plowed, subsoiled, and harrowed. Both Plats Nos. 2 and 3 were planted to Surprise oats on May 4th, irrigated June 27 and July 26, and harvested August 16. The results were as follows: Length of straw from both plats, 3.2 feet; length of stubble, .2 feet; yield of straw on Plat No. 2, 2,184

DIAGRAMS ILLUSTRATING TH

LARAMIE W



bs. per acre; on Plat No. 3, 2.209 lbs.; yield of grain on Plat o. 2, 1,193.7 lbs.; on Plat No. 3, 2,209.6 lbs.

The etching which accompanies this article, is, doubt-ess, self-explanatory. It may, however, be well to state hat the heavy dark lines extending from the bottom of the ge towards the top represent the amount of rainfall in nches, as indicated by the scale at the left.

In the tables which follow I have calculated the per ent of moisture in terms of the total weight of the soil as it ame from the field. I found that the amount of moisture in amples of the same soil taken the same day, and not more han 12 inches apart, varied from 2 to 4 per cent. In the bles the original figures are printed and not data from the raphical representations.

The first thing to be observed on the chart, perhaps, ill be the fact that the highest part of the curve is reached wo or three days after a heavy fall of rain, which is doubt-ess caused by seepage of water from a higher level, as the arm slopes toward the east about two feet in every hun-red. On the prairie sod, Plat No. 1, the general trend of he curve was down to about 5 per cent, which point it eached at the end of June. From this on till the end of the eason the curve fluctuated between 5 and 9 per cent.

Just before the first irrigation the moisture content of he soil from Plat No. 1 was about 8 per cent, from Plat No. 2 6½ per cent, and from Plat No. 3 7 per cent. Before he second irrigation the moisture content in Plat No. 1 was 7 per cent, in Plat No. 2 8 per cent, and Plat No. 3 7 er cent. At the end ofthe season we find that in the prairie od the moisture content was 6 per cent, while in the cultivated it was 6½ per cent, and in the subsoiled land 8½ per cent. After the first irrigation the moisture content fell during four days 8 per cent in the cultivated and 7½ per cent in the subsoiled ground; while after the second irrigation it fell the first four days only 3 per cent in the cultivated and 4 per cent in the subsoiled.

Moisture Content of Soil, Laramie Experiment Farm, Laramie, Wyoming, 1897.

PLAT NO. 1—PRAIRIE SOD.

Day	APRIL			MAY			JUNE			JULY			AUGUST			SEPTEMBER		
	Moisture	Rain	Evaporation	Moisture	Rain	Evaporation	Moisture	Rain	Evaporation	Moisture	Rain	Evaporation	Moisture	Rain	Evaporation	Moisture	Rain	Evaporation
	Per c'nt	*Inch's*	*Inch's*	*Per c'nt*	*Inch's*	*Inch's*	*Per c'nt*	*Inch's*	*Inch's*	*Per c'nt*	*Inch's*	*Inch's*	*Per c'nt*	*Inch's*	*Inch's*	*Per c'nt*	*Inch's*	*Inch's*
1.	...	...	...	12.76	...	0.14	11.97	0.02	0.13	3.11	...	0.12	6.24	0.04	0.12	6.41	...	0.12
2.	...	...	...	13.02	...	0.12	12.68	0.06	0.08	5.27	...	0.18	7.90	0.09	0.07	5.38	...	0.22
3.	...	...	...	12.34	...	0,11	11.07	0.12	0.12	7.59	...	0.19	9.67	0.42	0.10	5.58	...	0.12
4.	...	...	...	10.26	...	0.22	10.55	0.01	0.09	6.46	0.19	0.12	9.29	0.21	0.09	5.50	...	0.06
5.	...	...	...	...	...	0.09	10.90	0.02	0.00	7.44	...	0.18	9.26	0.12	0.18	6.50	...	0.18
6.	...	...	...	11.74	...	9.23	9.58	...	0.08	7.40	...	0.24	7.65	0.05	0.07	5.22	...	0.10
7.	...	...	...	10.19	0.01	0.09	9.53	...	0.10	7.93	...	0.22	8.86	...	0.20	6.08	...	0.14
8.	...	...	...	12.06	...	0.20	10.00	0.05	0.17	7.51	...	0.12	8.67	0.14	0.06	4.66	...	0.10
9.	...	...	...	8.59	...	0,17	11.72	0.14	0.10	6.33	0.20	0.10	8.95	...	0.04	5.55	...	0.10
10.	...	...	...	11.22	0.15	0.08	12.00	0.25	0.19	6.68	0.36	0.08	8.01	0.02	0.08	4.42	...	0.04
11.	...	...	...	8.50	...	0.05	14.17	...	0.10	8.65	...	0.42	8.46	...	0.08	8.01	0.31	0.13
12.	...	...	...	8.96	...	0.06	14.86		0.10	7.35	...	0.04	6.43	...	0.18	6.84	0.01	0.09
13.	...	...	...	9.53	...	0.20	...	...	0.10	6.64	...	0.26	5.56	...	0.12	7.82	...	0.06
14.	...	...	...	10.68	...	0.14	11.79	...	0.10	9.30	0.10	0.04	6.42	...	0.26	6.74	...	0.06
15.	...	...	...	9.15	0.02	0.08	9.26	...	0.30	6.07	...	0.14	5.50	...	0.16	7.83	...	0.12
16.	...	...	...	...	0.12	0.02	7.94	...	0.32	8.23	0.01	0.16	7.57	...	0.14	5.96	...	0.14
17.	...	...	...	7.63	...	0.14	11.05	...	0.16	5.85	...	0.12	5.39	...	0.14	5.10	...	0.16
18.	...	...	...	13.25	0.20	0.12	8.97	...	0.20	7.18	0.10	0.22	6.35	...	0.16	4.45	...	0.12
19.	...	...	...	11.81	...	0.16	7.88	...	0.24	7.07	...	0.08	3.86	...	0.20	5.52	...	0.08
20.	13.05	...	...	15.52	1.01	0.08	10.57	...	0.18	7.71	...	0.14	5.28	...	0.06	5.24	...	0.08
21.	13.03	...	...	15.50	0.12	0.08	7.63	0.05	0.07	8.68	...	0.06	4.76	...	0.14	5.28	...	0.08
22.	13.29	...	...	14.20	0.13	0.04	9.78	...	0.12	7.57	...	0.37	6.91	...	0.14	5.41	...	0.08
23.	14.28	0.15	...	14.20	...	0.14	7.58	...	0.16	8.23	0.03	0.06	6.63	...	0.12	5.06	...	0.08
24.	14.02	...	...	13.84	...	0.12	...	...	0.24	7 41	0.21	0.13	5.44	...	0.16	2.52	...	0.06
25.	13.92	...	0.42	13.55	...	0.10	...	...	0.18	8.16	..	0.12	6.03	...	0.28	4.97	...	0.14
26.	13.42	...	0.42	13.61	...	0.19	7.69	...	0.30	5.12	...	0.12	5.65	0.01	0.07	3.81	...	0.10
27.	8.40	...	0.34	...	...	0.11	7.15	...	0.22	5.91	...	0.16	4.77	0.01	0.05	4.25	...	0.12
28.	12.32	0.14	0.22	12.98	...	0.13	6.09	...	0.08	7.30	...	0.22	5.86	...	0.12	6.53	...	0.16
29.	13.52	0.07	0.02	12.40	...	0.10	6.12	...	0.24	6.22	...	0.08	4.91	...	0.16	5.60	...	0.08
30.	12.03	...	0.16	12.05	0.08	0.13	6.27	...	0.16	5.20	...	0.12	5.31	...	0.10	6.33	...	0.12
31.	...	...	...	13.35	...	0.08	...	...	...	6.75	0.09	0.23	5.77	...	0.20	...	...	...

Moisture Content of Soil, Laramie Experiment Farm, Laramie, Wyoming, 1897.

PLAT NO. 2—CULTIVATED.

Day	APRIL			MAY			JUNE			JULY			AUGUST			SEPTEMBER		
	Moisture	Rain	Evaporation	Moisture	Rain	Evaporation	Moisture	Rain	Evaporation	Moisture	Rain	Evaporation	Moisture	Rain	Evaporation	Moisture	Rain	Evaporation
	Per c'nt	*Inch's*	*Inch's*	*Per c'nt*	*Inch's*	*Inch's*	*Per c'nt*	*Inch's*	*Inch's*	*Per c'nt*	*Inch's*	*Inch's*	*Per c'nt*	*Inch's*	*Inch's*	*Per c'nt*	*Inch's*	*Inch's*
1.	....	...	...	11.57	...	0.14	10.88	0.02	0.13	13.67	...	0.12	11.60	0.04	0.12	7.53	...	0.12
2.	....	...	...	11.55	...	0.12	10.93	0.06	0.08	14.27	...	0.18	13.70	0.09	0.07	7.07	...	0.22
3.	....	...	...	11.84	...	0.11	11.83	0.12	0.12	14.23	0.19	0.19	15.25	0.42	0.10	6.14	...	0.12
4.	....	...	...	11.47	...	0.22	13.03	0.01	0.09	11.42	...	0.12	14.50	0.21	0.09	7.68	...	0.06
5.	....	...	...	....	...	0.09	8.99	0.02	0 00	13.22	...	0.18	14.60	0.12	0.18	7.03	...	0.18
6.	....	...	...	10 95	...	0.23	11.01	...	0.08	11.51	...	0.24	12.86	0.05	0.07	7.14	...	0.10
7.	....	...	...	11.89	0.01	0.09	11.28	...	0.10	11.12	...	0.22	14.98	...	0.20	8.55	...	0.14
8.	....	...	...	14.95	...	0 20	10.91	0.05	0.17	9.58	...	0.12	12.88	0.14	0.06	7.19	...	0.10
9.	....	...	...	11.85	...	0.17	12.90	0.14	0.10	9.77	0.20	0.10	12.96	...	0.04	8.55	...	0.10
10.	....	...	...	10.27	0.15	0.08	16.50	0.25	0.19	10.78	0.36	0.08	12.49	0.02	0.08	7.27	...	0.04
11.	....	...	...	12.76	...	0.05	14.76	...	0.10	11.50	...	0.42	13.06	...	0.08	12.15	0.31	0.13
12.	....	...	...	12.19	...	0.06	12 74	...	0.10	8.37	...	0.04	11.64	...	0.18	9.46	0.01	0.09
13.	....	...	...	10.30	...	0.20	....	...	0.10	7.52	...	0.26	9.40	...	0.12	8.35	...	0.06
14.	....	...	...	12.49	...	0.14	11.21	...	0.10	9.71	0.10	0.04	9.93	...	0.26	9.11	...	0.06
15.	....	...	...	13.36	0.02	0.08	9.05	...	0.30	8.40	...	0.14	10.08	...	0.16	9.92	...	0.12
16.	....	...	...	....	0.12	0.02	7.03	...	0.32	9.40	0.01	0.16	9.18	...	0.14	9 47	...	0.14
17.	....	...	...	11.35	...	0.14	11.14	...	0.16	7.42	...	0.12	8.80	...	0.14	7.76	...	0.16
18.	....	...	...	14.00	0.20	0.12	9.26	...	0.20	8.32	0.10	0.22	10.08	...	0.16	9.04	...	0.12
19.	....	...	...	12.97	...	0.16	8.87	...	0.24	8.03	...	0.08	10.68	...	0.20	4.28	...	0.08
20.	12.56	...	...	16.91	1.01	0.08	8.52	...	0.18	8.48	...	0.14	8.96	...	0.06	8.18	...	0.08
21.	13.46	...	...	14 34	0.12	0.08	8.23	0.05	0.07	8.50	...	0.06	8.15	...	0.14	6.98	...	0.08
22.	12.94	...	...	13.37	0.13	0.04	7.56	...	0.12	8.39	...	0.37	8.54	...	0.14	5.75	...	0.08
23.	12.86	0.15	...	13.47	...	0.14	8.09	...	0.16	9.05	0.03	0.06	9.98	...	0.12	7.05	...	0.08
24.	12.00	...	...	13.72	...	0.12	....	...	0.24	8.39	0.21	0.13	8.45	...	0.16	6.30	...	0.08
25.	13.66	...	0.42	13.82	...	0.10	....	...	0.18	8.73	...	0.12	7.65	...	0.28	5.20	...	0.14
26.	12.18	...	0.42	12.97	...	0.18	6.59	...	0.30	*	...	0.12	8.16	0.01	0.07	8.64	...	0.10
27	11.18	...	0.34	....	...	0.11	22.25*	...	0.22	17.08	...	0.16	8.49	0.01	0.05	5 43	...	0.12
29.	11.38	0.14	0.22	11.61	...	0.13	10.70	...	0.08	16.74	...	0.22	8.19	...	0.12	7.32	...	0.16
29.	12.53	0.07	0.02	11.27	...	0.10	15.76	...	0.14	15.04	...	0.08	6.75	...	0.16	4.34	...	0.08
30.	11.82	...	0.16	....	0.08	0.13	14.14	...	0.16	8.38	...	0.12	7.63	...	0.10	6.31	...	0.12
31.	....	...	...	11.07	...	0.08	....	...	...	15.53	0.09	0 23	....	...	0.20	....	...	...

*Irrigated.

Moisture Content of Soil, Laramie Experiment Farm, Laramie, Wyoming, 1897.

PLAT NO. 3—SUBSOILED.

Day	APRIL			MAY			JUNE			JULY			AUGUST			SEPTEMBER		
	Moisture	Rain	Evaporation	Moisture	Rain	Evaporation	Moisture	Rain	Evaporation	Moisture	Rain	Evaporation	Moisture	Rain	Evaporation	Moisture	Rain	Evaporation
	Per c'nt	*Inch's*	*Inch's*	*Per c'nt*	*Inch's*	*Inch's*	*Per c'nt*	*Inch's*	*Inch's*	*Per c'nt*	*Inch's*	*Inch's*	*Per c'nt*	*Inch's*	*Inch's*	*Per c'nt*	*Inch's*	*Inch's*
1..	......	......	......	10.83	......	0.14	10.87	0.02	0.13	14.09	......	0.12	11.39	0.04	0.12	6.59	......	0.12
2..	......	......	......	10.21	......	0.12	10.93	0.06	0.08	13.71	......	0.18	13.70	0.09	0.07	6.05	......	0.22
3..	......	......	......	10.83	......	0.11	12.22	0.12	0.12	14.05	0.19	0.19	15.52	0.42	0.10	6.52	......	0.12
4..	......	......	......	9.68	......	0.22	10.41	0.01	0.09	11.01	......	0.12	14.09	0.21	0.09	6.38	......	0.06
5.	......	......	......	......	......	0.09	11.15	0.02	0.00	11.86	......	0.18	14.97	0.12	0.18	6.43	......	0.18
6..	......	......	......	8.49	......	0.23	12.25	......	0.08	7.96	......	0.24	13.79	0.05	0.07	7.07	......	0.10
7..	......	......	......	9.09	0.01	0.09	11.45	......	0.10	9.49	......	0.22	11.45	......	0.20	6.22	......	0.14
8..	......	......	......	9.02	......	0.20	8.85	0.05	0.17	9.20	......	0.12	12.97	0.14	0.06	4.43	......	0.10
9..	......	......	......	9.91	......	0.17	10.71	0.14	0.10	9.86	0.20	0.10	13.37	......	0.04	6.72	......	0.10
10..	......	......	......	12.45	0.15	0.08	12.10	0.25	0.19	10.78	0.36	0.08	11.04	0.02	0.08	5.84	......	0.04
11	......	......	......	9.96	......	0.05	12.00	......	0.10	9.82	......	0.42	11.38	......	0.08	8.45	0.31	0.13
12..	......	......	......	9.78	......	0.06	9.11	......	0.10	8.80	......	0.04	10.28	......	0.18	7.99	0.01	0.09
13..	......	......	......	9.78	......	0.20	......	......	0.10	9.24	......	0.26	9.26	......	0.12	8.78	......	0.06
14..	......	......	......	10.92	......	0.14	11.41	......	0.10	8.79	0.10	0.04	10.04	......	0.26	8.51	......	0.06
15..	......	......	......	10.30	0.02	0.08	9.61	......	0.30	9.00	......	0.14	8.97	......	0.16	8.39	......	0.12
16..	......	......	......	......	0.12	0.02	8.55	......	0.32	8.47	0.01	0.16	10.83	......	0.14	6.75	......	0.14
17..	......	......	......	10.00	......	0.14	10.40	......	0.16	6.98	......	0.12	8.68	......	0.14	6.65	......	0.16
18..	......	......	......	11.12	0.20	0.12	6.96	......	0.20	6.38	0.10	0.22	9.34	......	0.16	5.86		0.12
19..	......	......	......	11.54	......	0.16	9.55	......	0.24	7.39	......	0.08	9.33	......	0.20	8.16	......	0.08
20..	11.59	......	......	17.35	1.01	0.08	7.95	......	0.18	7.29	......	0.14	6.49	......	0.06	8.75	......	0.08
21..	11.03	......	......	13.59	0.12	0.08	7.22	0.05	0.07	8.93	......	0.06	7.90	......	0.14	9.81	......	0.08
22..	11.30	......	......	13.91	0.13	0.04	7.90	......	0.12	7.22	......	0.37	8.05	......	0.14	6.42	......	0.08
23..	15.09	0.15	......	13.64	......	0.14	6.03	......	0.16	8.40	0.03	0.06	7.36	......	0.12	5.55	......	0.08
24..	12.68	......	......	13.95	......	0.12	......	......	0.24	6.97	0.21	0.13	7.49	......	0.16	6.02	......	0.06
25..	13.59	......	0.42	11.78	......	0.10	......	......	0.18	8.37	......	0.12	9.65	......	0.28	6.83	......	0.14
26..	13.31	......	0.42	12.72	......	0.18	7.44	......	0.30	*	......	0.12	6.40	0.01	0.07	7.08	......	0 10
27..	11.43	......	0.34	......	......	0.11	21.15*	......	0.22	16.97	......	0.16	8 62	0.01	0 05	6.48	......	0.12
28..	10.09	0.14	0.22	10.43	......	0.13	21.76	......	0.08	16.90	......	0.22	6.90	......	0.12	6.64	......	0.16
29..	11.49	0.07	0.02	9.50	......	0.10	16.23	......	0.14	14.79	......	0.08	6.57	......	0.16	8.40	......	0.08
20	10.56	......	0.16	12.27	0.08	0.13	16.37	......	0.16	10.52	......	0.12	7.37	......	0.10	6.95	......	0.12
31..	......	......	......	12.23	......	0.08	......	......	......	12.46	0.09	0.23	......	......	0.20	......	......	..

*Irrigated.

UNIVERSITY OF WYOMING.

Agricultural College Department.

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WYOMING SUGAR BEETS.

BY E. E. SLOSSON.

Bulletins will be sent free upon request. Address: Director Experiment Station, Laramie, Wyo.

Wyoming Agricultural Experiment Station.

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WYOMING SUGAR BEETS.

BY E. E. SLOSSON.

So many inquiries have been received by this Station asking whether sugar beets can be raised successfully in Wyoming and whether it is possible to establish factories here, that the earlier bulletins on the subject have long been out of print and it becomes necessary to issue another bulletin to include a summary of all the experiments made in raising sugar beets, and to give sufficient data on the sugar beet industry for our farmers and land owners to decide on its practicability.

The Station has raised sugar beets on the experiment farms in different parts of the state for seven years, and besides this, sugar beet seed has been distributed free of charge almost every year to all farmers who would agree to try raising beets and would send samples for analysis. The results obtained by the free distribution of seed have been uncertain and unsatisfactory. Not very many farmers have expressed a willingness to coöperate with the station in this way, and of those who were given seed and agreed to report and send samples, only a small proportion, from a tenth to a third, have been heard from since. We are therefore all the more grateful to those who have complied with the conditions and thus assisted the Station in its efforts to give the experiments wider range.

This year a limited amount of sugar beet seed will be distributed, but care will be taken that it is sent only to responsible parties who will give it a fair trial and report results whether good or bad.

The following tables give all the experiments in sugar beet culture in Wyoming of which we have record. Although they are few, yet, covering as they do so many years of varying weather and representing all the principal agricultural regions of the state, they give a basis for a pretty accurate judgment of what may be expected of this branch of agriculture. Some of the analyses of each year, and all of those of 1897, were made by the Department of Agriculture at Washington. The rest were analyzed in the Chemical Laboratory of the University of Wyoming.

Yields reported by private parties are all excluded, as some of them are manifestly incorrect and there was no way of judging how accurate the rest were. The yields from the experiment farms were calculated from actual weights of the crop from plats of known area. The average does not, however, represent exactly what may be expected in practice, for beets of many varieties, some of them inferior, were grown, and several methods of cultivation and kinds of soil were tested. Since the unsuccessful are included with the successful, the average yield is less than if approved seed and methods of cultivation had been used. On the other hand, in part of the experiments only small plats were used, which gives an inaccurate, generally excessive, yield per acre. On the whole, the averages of yields are believed to give a fair, though only approximate, idea of the production of sugar beets in the localities represented by the experiment farms during the period of seven years.

EXPLANATION OF TERMS.

In analyzing beets the juice is extracted and its specific gravity determined; that is, its weight compared with an equal volume of water. From this is calculated the per cent of solid matter, including sugar, in the juice. The amount of sugar is then determined by the polariscope. Since about 95 per cent of the beet is juice, subtracting five per cent of this gives the per cent sugar in the beet. Dividing the per cent sugar in the juice by the total solids in the juice gives the "purity." For example, if there are 20 per cent of solid matter and 15 per cent of sugar, the purity is 15 divided by 20, or 75.

Results of Sugar Beet Culture in Wyoming.

Year	Place.	Grown by	Variety	Yield, tons per acre	Per cent sugar in beets	Purity
1891.	Laramie	Experiment Farm	La Plus Riche	3.3	11.1	67.0
"	"	" "	" "	"	15.3	81.7
"	"	" "	Kleinwanzlebener	3.9	12.2	69.5
"	"	" "	"	"	15.1	83.4
"	"	" "	Desprez	3.5	13.9	71.5
"	"	" "	"	"	14.7	83.1
"	"	" "	Vilmorin Improved	4.3	15.1	68.5
"	"	" "	" "	"	15.0	77.0
"	"	" "	" "	"	16.0	82.7
"	"	" "	Kleinwanzlebener	4.1	13.3	65.7
"	"	" "	"	"	15.1	80.3
"	"	" "	"	8.9	16.0	70.0
"	"	" "	"	"	10.3	74.1
"	"	" "	"	"	13.3	65.7
"	"	" "	"	"	13.8	82.4
"	"	" "	Vilmorin Improved	...	11.9	65.7
"	"	" "	" "	...	12.1	74.7
"	"	" "	Silesian	3.1	12.4	78.9
"	"	" "	"	"	14.1	75.8
"	Lander	" "	...	...	12.8	80.7
"	Sundance	" "	Simon's La Grande	5.8	16.9	82.0
"	"	" "	" "	"	15.5	79.6
"	"	" "	" "	"	19.0	85.6
"	"	" "	...	"	14.0	75.8
"	"	" "	...	"	16.3	78.2
"	"	" "	...	"	14.8	77.1
"	"	" "	White French	"	13.7	77.4
"	"	" "	" "	"	15.7	79.1
"	"	" "	" "	"	15.3	84.1
"	"	" "	Desprez	"	14.7	77.1
"	"	" "	"	"	18.0	78.4
"	"	" "	"	"	17.7	79.5
"	"	" "	White French	...	12.5	68.8
"	"	" "	" "	...	11.1	67.6
"	"	" "	" "	...	15.9	73.7
"	Laramie	Terry Fee	Vilmorin Improved	...	14.5	75.4
"	"	" "	" "	...	12.4	73.4
"	"	" "	" "	...	12.5	73.5
"	"	" "	" "	...	13.2	75.7
"	"	Experiment Farm	Lane's Improved	7.0	12.8	75.8
"	Saratoga	" "	Vilmorin Improved	17.4	15.1	80.1
"	"	" "	" "	"	15.5	82.7
"	"	" "	" "	"	11.4	77.9
"	Cooper	E. S. R. Boughton	...	...	13.8	77.4
"	"	" "	...	...	16.0	78.4
"	"	" "	...	...	13.0	72.9
"	"	" "	...	...	15.8	77.8
"	"	" "	...	...	19.9	80.7
"	"	" "	...	...	14.4	70.4
"	Wheatland	Experiment Farm	Kleinwanzlebener	...	16.9	88.2
"	"	" "	"	...	14.1	84.3
"	"	" "	"	...	13.0	80.7
"	"	" "	...	1.8	22.5	89.9
"	"	" "	...	"	21.3	90.1
"	"	" "	Vilmorin Improved	7.2	19.5	88.0
"	"	" "	" "	"	22.0	86.9
"	"	" "	" "	"	21.6	84.3
"	Laramie	A. Fisher	...	...	20.8	86.6
"	"	" "	...	...	13.7	74.7

Results of Sugar Beet Culture in Wyoming—(Continued.)

Year	Place.	Grown by	Variety	Yield, tons per acre	Per cent sugar in beets	Purity
1891	Sheridan	Experiment Farm	. . . .	. . .	17.5	85.5
"	"	" "	. . . .	. . .	14.4	86.6
"	Lander	" "	. . . .	. . .	17.8	85.6
"	"	" "	. . . .	. . .	18.2	85.3
"	Sundance	" "	French	. . .	11.3	77.5
"	Crook County	C. E. Lincoln	Vilmorin Improved	. . .	13.3	70.8
"	" "	" "	Kleinwanzlebener	. . .	14.9	73.3
"	Johnson County	S. Morgridge	French	. . .	13.3	77.2
"	Laramie County	R. M. Walker	"	. . .	9.4	72.5
"	" "	A. C. Hubbard	Vilmorin Improved	. . .	14.2	77.2
"	" "	" "	Kleinwanzlebener	. . .	12.8	70.2
"	Sheridan	Experiment Farm	. . . .	. . .	13.8	80.0
1892	Laramie	Experiment Farm	Vilmorin Improved	8.6	8.8	64.1
"	"	" "	" "	"	10.0	70.5
"	"	" "	" "	"	11.1	72.4
"	"	" "	" "	"	12.7	74.9
"	"	" "	" "	"	12.6	76.0
"	"	" "	" "	"	13.6	74.1
"	"	" "	" "	"	12.6	71.9
"	"	" "	" "	"	14.2	76.1
"	"	" "	Kleinwanzlebener	9.3	8.6	64.3
"	"	" "	"	"	9.2	70.3
"	"	" "	"	"	12.6	78.3
"	"	" "	"	"	13.1	77.2
"	"	" "	"	"	13.1	74.2
"	"	" "	"	"	16.1	78.6
"	"	" "	Lane's Imperial	10.8	15.6	81.1
"	"	" "	" "	"	12.5	72.9
"	"	James King	Kleinwanzlebener	. .	16.1	77.8
"	"	" "	"	. . .	15.2	75.0
"	Saratoga	Experiment Farm	"	8.0	12.7	71.2
"	"	" "	"	"	12.0	69.6
"	"	" "	"	"	18.3	83.3
"	Wheatland	" "	"	11.8	16.9	84.5
"	"	" "	"	"	14.2	82.3
"	"	" "	"	"	14.8	81.8
"	"	" "	"	"	20.8	90.5
"	"	" "	Vilmorin Improved	14.6	18.7	82.6
"	"	" "	" "	"	16.0	87.7
"	"	" "	" "	"	21.5	86.9
"	"	" "	Lane's Imperial	10.9	14.9	78.7
"	"	" "	" "	"	14.8	86.2
"	"	" "	" "	"	14.0	81.5
"	"	" "	" "	"	19.0	87.7
"	Sundance	" "	Kleinwanzlebener	4.3	14.2	67.6
"	"	" "	"	"	13.2	71.8
"	"	" "	White French	6.6	9.6	66.2
"	"	" "	Vilmorin Improved	2.3	14.6	82.1
"	"	" "	" "	"	14.0	76.7
"	"	" "	Lane's Imperial	6.5	11.4	63.3
"	"	" "	" "	"	9.5	60.6
"	Sheridan	" "	French Yellow	19.0	15.3	74.0
"	"	" "	" "	"	19.6	78.9
"	"	" "	Lane's Imperial	12.5	17.1	77.6
"	"	" "	French White	15.1	21.6	84.8
"	"	" "	" "	"	21.4	84.3
"	"	" "	Kleinwanzlebener	12.0	23.0	86.6
"	"	" "	"	"	21.0	86.6

Results of Sugar Beet Culture in Wyoming—(Continued.)

Year	Place	Grown by	Variety	Yield, tons per acre	Per cent sugar in beets	Purity
1892.	Sheridan	Experiment Farm	Vilmorin Improved	20.1	19.9	85.4
"	"	" "	" "	"	18.6	87.9
"	"	" "	Lane's Imperial	12.5	18.3	85.9
"	"	" "	" "	"	17.1	87.6
"	"	" "	French Yellow	19.0	18.2	74.4
"	"	" "	French White	...	17.2	87.2
"	Hatton	C. A. Chase	...	...	20.8	86.2
"	Torrey	Ed Cussack	Vilmorin Improved	...	17.1	76.6
"	"	" "	" "	...	20.9	83.8
"	Forks	A. D. Brown	Kleinwanzlebener	...	16.3	78.3
"	"	" "	"	...	13.3	74.4
"	Mountain View	M. Manley	Vilmorin Improved	...	20.6	85.5
"	" "	" "	" "	...	18.3	79.9
"	Leo	J. W. Bennett	Kleinwanzlebener	...	11.7	75.6
"	"	" "	"	...	12.0	82.2
"	"	" "	"	...	13.9	76.8
"	Inyan Kara	S. A. Young	Vilmorin Improved	...	17.1	72.6
"	Beaver	Chas. Rice	" "	...	23.3	85.3
"	Ohlman	R. Niver	Kleinwanzlebener	...	19.9	87.1
"	"	" "	"	...	21.6	86.0
"	Laramie	R. Henke	"	...	17.3	85.5
"	Cheyenne	H. H. Hood	...	...	15.0	71.7
"	"	" "	...	...	14.1	72.9
"	Big Horn	R. M. Hays	...	...	21.2	87.0
"	" "	" "	...	...	19.0	85.6
1893.	Laramie	Experiment Farm	Vilmorin Richest	...	13.1	78.8
"	"	" "	Kleinwanzlebener	...	12.5	75 9
"	"	" "	Knauer Imperial	...	12.3	75.9
"	Sybille	Alfred Bridger	Vilmorin Richest	...	15.7	79.1
"	Saratoga	Experiment Farm	Kleinwanzlebener	16.3	16.0	81.5
"	"	" "	Improved Bulteau	13.6	16.8	83.9
"	"	" "	" "	"	20.1	82.7
"	"	" "	Vilmorin Richest	16.3	15.0	85.0
"	"	" "	" "	"	21.4	86.1
"	"	" "	Kleinwanzlebener	"	15.9	84.8
"	Sundance	" "	"	3.1	13.4	72.3
"	"	" "	"	3.0	17.1	76.0
"	"	" "	"	"	15.4	76.0
"	"	" "	"	"	13.8	73.7
"	"	" "	Vilmorin Richest	3.8	14.9	72.0
"	"	" "	" "	"	16.9	87.8
"	Lander	" "	" "	20.5	15.4	77.4
"	"	" "	Knauer's Imperial	21.0	15.6	80.9
"	"	" "	Kleinwanzlebener	24.0	15.1	78.7
"	"	" "	Improved Bulteau	20.5	15.0	83.1
"	"	" "	" "	"	14.9	85.4
"	Wheatland	" "	Vilmorin Richest	6.2	17.7	86.9
"	"	" "	" "	"	21.6	86.1
"	"	" "	Knauer's Imperial	6.8	16.9	85.1
"	"	" "	Kleinwanzlebener	"	21.2	86.4
"	"	" "	Improved Bulteau	6.0	21.8	89.1
"	Sheridan	" "	" "	10.5	13.0	78.0
"	"	" "	" "	"	17.0	86.3
"	"	" "	" "	"	17.1	82.0
"	"	" "	Kleinwanzlebener	17.0	16.3	86.1
"	"	" "	"	"	16.8	78.9
"	Afton	John Astle	Desprez No. 2	...	12.9	81.5
"	Mountain View	M. Manley	Kleinwanzlebener	...	13.1	72.4

Results of Sugar Beet Culture in Wyoming—(Continued.)

Year	Place	Grown by	Variety	Yield, tons per acre	Per cent sugar in beets	Purity
1894	Laramie	Experiment Farm	Kleinwanzlebener	7.9	15.6	80.4
"	"	" "	Vilmorin Improved	12.6	16.9	84.4
"	"	" "	White Silesian	8.6	15.0	81.0
"	"	" "	New Danish	...	12.8	75.4
"	"	" "	Meltee	14.0	15.8	81.7
"	Sheridan	" "	Vilmorin Improved	11.1	21.6	80.3
"	"	" "	Kleinwanzlebener	9.8	20.7	85.8
"	"	" "	White Silesian	8.5	19.0	88.6
"	"	" "	Meltee	15.6	20.6	89.6
"	Sundance	" "	White Silesian	5.3	...	...
"	"	" "	Vilmorin Improved	2.9	...	...
"	"	" "	Kleinwanzlebener	4.3	...	...
"	Wheatland	" "	Knauer's Imperial	11.0	...	...
"	"	" "	Kleinwanzlebener	12.0	...	...
1895	Laramie	Experiment Farm	Kleinwanzlebener	5.8	13.9	80.7
"	"	" "	Improved Keilholz	1.5	11.7	75.0
"	"	" "	Improved Lion	3.7	13.7	77.0
"	"	" "	Keilholz Imperial	5.3	...	...
"	Sundance	" "	Kleinwanzlebener	6.2	...	...
"	Lander	" "	"	5.4	...	...
"	"	" "	"	23.2	...	...
"	"	" "	"	20.3	...	...
"	"	" "	Vilmorin Improved	19.6	...	...
"	"	" "	Hayne's Improved	17.4	...	...
"	"	" "	Kleinwanzlebener	...	...	...
1896	Laramie	Experiment Farm	Kleinwanzlebener	9.4	...	...
"	"	" "	Ertragreicher	0.0	...	...
"	"	" "	Improved Keilholz	4.6	...	...
"	"	" "	Keilholz Imperial	8.4	...	...
"	"	" "	Keilholz Lion	6.2	...	...
"	"	" "	Zucherreicher	0.0	...	...
"	Sheridan	" "	...	5.9	...	...
"	"	" "	...	7.3	...	...
1897	Laramie	James King	Kleinwanzlebener	...	12.2	77.3
"	"	Experiment Farm	"	7.2	19.7	88.1
"	"	" "	"	5.8	19.0	89.2
"	"	" "	"	6.4	20.3	92.1
"	Centennial	A. L. Foster	"	...	22.3	...
"	Fenton	W. Thayer	"	...	15.8	83.4
"	Shell	Peter Enders	"	...	18.5	85.0
"	Fenton	W. Thayer	"	...	22.7	87.2
"	Bonanza	O. C. Morgan	"	...	20.4	85.3
"	"	J. E. Heron	"	...	12.0	70.2
"	Burlington	W. E. Guylamp	"	...	22.6	...
"	Coreyhurst	J. M. Carey	"	...	16.0	84.0
"	Douglas	Robt. Fryer	"	...	17.9	83.5
"	"	J. A. Brockway	"	...	24.3	...
"	"	Alex. Brockway	"	...	17.0	77.7
"	"	Willard Virdin	"	...	18.1	86.3
"	"	J. M. Brockway	"	...	19.0	83.2
"	"	David Brockway	"	...	15.8	...
"	Orin	F. M. Haynes	"	...	16.3	80.2
"	Douglas	Robt. Fryer	"	...	15.6	80.4
"	Sundance	Lawrence Mauch	"	...	17.1	...
"	Lander	Experiment Farm	"	...	12.5	72.0
"	Buffalo	J. A. Fisher	"	...	11.3	75.2

Results of Sugar Beet Culture in Wyoming—(Continued.)

Year	Place	Grown by	Variety	Yield, tons per acre	Per cent sugar in beets	Purity
1897.	Buffalo	J. A. Fisher	Kleinwanzlebener	. . .	9.1	. . .
"	"	E. P. Gossett	"	. . .	13.4	76.9
"	Wheatland	W. J. Hooston	"	. . .	15.5	79.5
"	"	G. W. Watkins	"	. . .	17.1	86.9
"	"	S. V. Moody	"	. . .	16.8	85.8
"	"	G. F. Frederick	"	. . .	14.7	81.0
"	Freeland.	C. M. Cheney	"	. . .	17.3	78.6
"	"	" "	"	. . .	19.6	. . .
"	Dayton	R. A. Frazier	"	. . .	16.2	. . .
"	"	" "	"	. . .	19.6	. . .
"	Sheridan.	Experiment Farm	"	12.4	18.0	89.1

Comparatiue Table Showing Results of Sugar Beet Culture on the Experiment Farms from 1891 to 1897, Inclusive.

EXPERIMENT FARM.	Average yield, tons per acre	Average per cent sugar in beets	Average purity
Lander.	19.24	15.25	81.01
Laramie.	5.09	13.26	75.50
Sheridan.	13.25	18.36	83.93
Sundance.	4.50	14.76	75.34
Wheatland.	9.61	17.85	85.20

DISCUSSION OF RESULTS.

From this table it will be seen that the region about Sundance, when irrigation is not possible, and the elevated plateau along the Union Pacific represented by Laramie, do not give satisfactory results. While the yield and quality of the beets given in the table is below what might be expected in farming in the ordinary way, yet large crops cannot be depended upon in either of these localities. The Lander valley gives remarkably good results, but on account of lack of railroad facilities it would be impracticable to establish a factory there at present. For the same reason the Big Horn valley must wait, although from its resemblance to the Sheridan district and from the good results obtained this year and reported in the preceding pages, it would prove well suited to beet growing. The Wheatland

and Sheridan farms have given every year good yields and the beets are of extraordinary richness and purity, and there seems to be no reason why factories in their vicinity should not be successful.

Irrigated land has a great many advantages over land depending on the caprice of nature for its water supply. Sugar beets require a large and continuous supply of water during the early part of the growing season, while abundant rains in the autumn lower the sugar content very materially. Many instances have occurred where crops were severely injured by late rains, and the newspapers report that one of the largest sugar factories in the west will remain idle this season on account of drought. Sugar beets are injured by too warm weather, but require an abundance of sunshine, of which in this country there is no lack. One disadvantage of the climate of Wyoming is the shortness of the season, on account of which beets do not always have time to fully mature, and crops cannot be put in at different times so as to secure succession of ripe beets at the factory while in operation. It would probably be necessary to put most of the beets in silos. An objection often raised against growing beets in the arid region is the presence of alkali. According to our experience, the alkali in this state, which consists chiefly of sodium and magnesium sulphate, does not interfere with the growth of the beets or perceptibly impair their quality. Good crops of satisfactory richness have many times been grown in ground strongly impregnated with soluble salts, and in 1897 an experiment bearing directly on this point was carried out on the Laramie farm. Three plats were planted; two of them were of the best land of the farm, and of these one was cultivated in the ordinary way and the other was subsoiled. The third plat was of the worst alkali land that could be found and on which most crops could not be grown at all. The results were as follows:

	Yield	Per cent sugar in beets	Purity
Alkali land	7.2	19.0	89.2
Good land, subsoiled	6.4	19.7	88.2
Good land, not subsoiled	5.8	20.3	92.7

IMPORTANCE OF THE BEET SUGAR INDUSTRY.

The rise of the beet sugar industry is a remarkable example of what can be accomplished by science applied to agriculture. In the beginning nothing could seem more hopeless than that sugar beet could compete with cane sugar. The beets contained only about six to eight per cent of sugar, the impurities could only be removed by difficult chemical processes, and to grow the beets properly required skilled and expensive labor. The sugar cane, on the contrary, was rich and grew with tropical luxuriance, while the harvesting and sugar making was done by the cheapest labor in the world. Today out of 7,000,000 tons of sugar produced annually, about 5,000,000 tons are made from beets. Within the last ten years there has been an increase of 50 per cent in the world's production of sugar and in consequence of its lower price a corresponding increase in consumption. The United States consumes annually about 2,000,000 tons, or 64 pounds a year for each man, woman, and child. At present about 84 per cent of this is imported, but if the beet sugar industry continues to develop we will in time be growing our own supply of sugar.

The following figures show the amount of sugar produced from cane and beets during the past four years in the United States:

	Beet	Cane
1894-5	20,000 tons	317,000 tons
1895-6	30.000 "	237 000 "
1896-7	40.000 "	275,000 "
1897-8	70,000 "	287,000 "

To supply the United States with sugar from beets would require a million acres of that crop and 500 factories, so there is no danger of over-production. Whether the price of the product will be much lower in the future than it is now depends, of course, on competition, invention, and legislation, and it would be unsafe for anyone to make a prediction in regard to it.

PROCESS OF MANUFACTURE.

The conditions under which a beet sugar factory would be successful can be better understood if a brief description is given of the process of extracting the sugar from the beets. The beets, on being received at the factory, are sampled, analyzed, and the tare or deduction for dirt determined. They are then floated in a flume to the washer and after being thoroughly cleaned are sliced into thin triangular pieces known as cossettes. These are packed into a diffusion battery consisting of ten to fourteen cells holding about two tons each. A continuous stream of hot water is passed through the battery in such a way that the fresh water enters the cell where the cossettes are most nearly exhausted. When all the sugar has been extracted in this way the cossettes are pressed and used as cattle food. The water extracts from the beets not only the sugar but also a number of impurities which must be gotten rid of before crystallizing out the sugar. The juice is first treated with two or more per cent of slaked lime and the excess of lime precipitated by passing in carbonic acid gas. After filtering under pressure, the juice is again treated with a smaller quantity of lime and finally with sulphurous acid gas to completely decolorize it. By evaporating off the water from the purified solution sugar is obtained. This process is not, however, as simple as it seems, for it would take too long to evaporate it at low temperature, while if it were boiled the sugar would burn. This difficulty is obviated by reducing the pressure and boiling off the water at low temperature in a partial vacuum. This is done in a series of three or four tanks, the steam from one serving to boil the next. The final evaporation is done in a large "vacuum pan," holding some thirty-five tons, and when the crystals of sugar have become of the proper size the sugar is separated from the molasses by a centrifugal machine and dried.

PRICES PAID FOR BEETS.

Under present conditions sugar making pays a good profit to both manufacturer and farmer. A sugar factory of average capacity pays out thirty or forty thousand dollars in wages during the season and farmers receive about four dollars a ton for the beets. The price paid for beets usually varies with their quality, since it costs more to extract the sugar from poor beets than from rich ones, and the manufacturers make great efforts to induce the farmers to work for quality rather than quantity. Two things are taken into consideration, the total amount of sugar in the beets and the purity of the juice. At the Nebraska factories this year the rates are as follows:

12 to 14 per cent sugar, purity not less than 78.......	$4.00
14.5 to 15.4 per cent sugar, purity not less than 78....	4.25
15.5 to 16.4 per cent sugar, purity not less than 78....	4.50
etc., etc.	

A reduction of 50 cents per ton for each per cent of sugar below 12, and a reduction of 15 cents a ton for each degree of purity below 78. No beets are received containing less than 10 per cent sugar and of less than 73 purity.

The Alamitos and Chino, California, factories pay $3.00 and $3.35 a ton for 12 per cent beets, with 25 cents a ton increase for each per cent above 12. In order to maintain a high quality of beets the seed is grown only from pedigreed beets whose sugar content is determined by actual analysis. The beet seed is mostly imported at present and is supplied free by the factory at the rate of 15 to 20 pounds to the acre.

REQUIREMENTS OF A SUGAR FACTORY.

The manufacture of beet sugar requires large capital, expert control, and efficient management. The plant is expensive,the working season is short,only about 100 days,and the margin of profit is small in proportion to the amount of the product. The cultivation of the sugar beet requires more intelligent farming than is customary in the United States, and for the first two or three years after the establishment of the factory the education of the farmers in the vicinity is an important part of the work. Small factories do not pay and the tendency in this country is toward building larger factories each year. A factory capable of working 350 or 400 tons of beets a day is as small as is profitable and will cost about $300,000 to $400,000. To supply such a factory 3,000 to 5,000 acres are required, most of which must be within easy hauling distance. The beets can be shipped by railroad a short distance if cheap enough rates can be secured. They should be delivered day by day as the factory requires them, to avoid storage, and should not be allowed to freeze. There must be an abundant supply of pure water. About 2,000,000 gallons a day is used by a factory of the size under discussion. From 45 to 50 tons of coal are used every day and several tons of coke for burning the limestone. At Chino, California, where oil is used for fuel, about 80,000 barrels are required for the season. To supply the lime for purification, twenty or twenty-five tons of limestone are burned per day.

LOCATION OF A FACTORY IN WYOMING.

The question is often asked of the Station whether a sugar factory would be profitable in some particular part of the state, and these figures are given so that people can calculate for themselves the probable success of such an enterprise. It is evident that a locality to support a factory must not only have a sufficient amount of land suitable for growing good beets, but must also have railroad facilities and a supply of coal, lime, and water in the immediate vicinity. In a state undeveloped, and, we may even say, unexplored, as Wyoming is, it is not possible to say how much of the state will be found suited to this industry, but it is not making any invidious distinctions to point out that there are at least two localities that meet all the requirements. These are the irrigated land near Wheatland and Douglas, and that in the vicinity of Sheridan. It should also be mentioned that some of the chemicals used in the purification of sugar could also be obtained within the bounds of the state. Sal soda, of which some 6,000 pounds are required, can be prepared at Green River by simple evaporation. About 30,000 pounds of sulphur are also needed and could be obtained from Uinta county with very little trouble.

The duty of the Experiment Station is to investigate a proposed branch of agriculture and report to the people the facts discovered, whether favorable or unfavorable. Experimenting on sugar beet culture has been carried on continuously ever since the Station was established, and four bulletins have been issued on the subject. If some localities are not represented it is not the fault of the Station, for offers of free beet seed for experimental purposes have been made almost every year, in the newspapers of the state. This year a smaller amount of beet seed is on hand for distribution to those who are willing to try it and send samples for analysis. Directions for the culture of the sugar beet are appended to this bulletin. A crop of sugar beets is valuable even when there is no factory. They are better for table use than the red beet and are raised on a large scale in many places for cattle food. Five thousand Wyoming cattle were fattened in Nebraska one year on sugar beets raised for that purpose.

The Station will be pleased to coöperate with any locality which contemplates establishing a sugar factory, either by a visit of some member of the staff to lecture and make a detailed reconnoissance, or by giving such information as may be desired as to machinery and where it can be obtained.

LITERATURE OF THE SUBJECT.

Those who are interested will find the following publications useful and reliable: U. S. Department of Agriculture, "The Sugar Beet," Farmer's Bulletin No. 52 (free.) Most of the Stations in the sugar beet belt have issued bulletins on the subject this year which can be had on application to the respective stations. Bulletin No. 40 of the Illinois Station, Urbana, Ill., and Bulletin No. 135 of the New York Station, Geneva, N. Y., give a good deal of general information. The periodicals "The Sugar Beet," Philadelphia, (monthly), and "The Louisiana Planter," New Orleans, (weekly) are of value both for articles and advertisements. A pamphlet, "American Beet Sugar," by W. H. Holabird, Los Angeles, California, gives good pictures of the manufacture. "The Sugar Beet," by Ware (H. C. Baird, Philadelphia), and "Sugar," by Myrick (Orange Judd Co., Chicago), are among the best books on the subject.

Method of Cultivation.

BY B. C. BUFFUM.

SOIL:—Take the best soil on the farm. A sandy loam is best, but do not use land so sandy that it shifts with the wind or dries out too much. The soil should be deep and with good drainage. If it has a dressing of stable manure, so much the better, especially if it was applied to a crop last year. If applied this year, do not put on too much. Land plowed last fall is preferable. The earlier and deeper it is plowed the better. It should be plowed long enough before seeding to allow it to settle. Before seeding, harrow thoroughly to make a well pulverized, mellow seed-bed, and to kill all young weeds.

PLANTING:—The seed should be planted in May; from the 10th to the 20th is recommended, if the soil is in the right condition to work. If the soil is very dry or likely to become so, it is well to leave a shallow furrow between each row of seed, so that the plants may be irrigated up, but this should not be resorted to unless absolutely necessary. If obliged to irrigate to bring the seed up, do not allow the soil to dry out and form a crust. Cultivate the surface as soon as the plants are up enough to show the rows distinctly. Plant the seed in rows from fifteen to twenty inches apart and from one to three inches deep. A hand seed drill is best. After planting, the rows should be tramped upon to firm the soil around the seed. If planted by hand, drop the seed in shallow furrows, cover with a hand plow or hoe, and tramp the soil, to firm it around the seed.

CULTIVATION:—This should begin as early as possible and should occur often enough to keep down all weeds and keep the ground mellow. Beets require thorough cultivation. After trimming, during June and July, the cultivation should reach a depth of six inches. Cultivate shallow as soon after irrigating as the ground can be worked, and cultivate deep before the next irrigation. Care should be taken not to break the leaves or to throw the soil against the plants, hilling them up, as they need flat cultivation to give them all the air and sunshine they can get.

THINNING:—When the beets have developed four leaves, they should be thinned. This is best done by first going through the rows with a hoe, cutting out from four to six inches of beets, and leaving bunches between that contain a number of plants. After bunching in this way, thin by pulling out all but the largest and healthiest beet in each bunch.

IRRIGATION:—Beets require considerable water during the growing period in June, July, and August. They should not be kept so wet that the ground becomes sour or soggy, or contains so much water that it cannot be kept in a good state of tilth and well aerated by cultivation. Nor should the soil be allowed to get so dry that all the leaves wilt. Irrigate in furrows made between the rows in such a way that the water will not flood over or around the crowns of the beets. Cultivate as soon after each irrigation as the ground gets dry enough to work. Run the cultivator shallow to break up the surface crust.

Do not irrigate until the beets show unmistakable signs of needing moisture, as irrigating too soon or too often is apt to spoil both the shape and quality. When the bottom leaves begin to wilt and the top ones to turn a dark green, they need water. If the tops have a light greenish yellow appearance, they have been kept too wet. They probably will need from three to five irrigations. The number of times necessary will depend upon the supply of moisture. They should not be irrigated later than the last of August, as the beets require dry, sunny weather during September, to ripen and store up a large per cent of sugar in the juice.

HARVESTING:—The beets should be mature about the first of October. Ripening is indicated by the outer leaves turning yellow and dying. They should be harvested in October before hard freezing weather. If a hard freeze occurs, they should not be taken from the ground until thawed out, as in this way the frost will leave the beets gradually without destroying them. Loosening the soil between the rows with a narrow plow will enable the beets to be pulled without bruising them. Cut off the tops squarely with a little of the rough portion of the beets. The best size is from one to three pounds. If they weigh over four pounds they are apt to be poor in sugar. Beets may be stored in root cellars or in pits in the ground, like potatoes or other root crops. They keep better if covered with soil which comes in contact with the beets, as this prevents wilting. If stored in pits for any length of time, they should be covered with five or six inches of soil, then a layer of straw of the same thickness, and more soil over the straw as the weather gets very cold. Where placed in pits or silos, a hole must be left in the top for ventilation, filling it with straw or sacks, instead of with soil, as cold weather comes on.

Directions for taking samples for analysis will be printed on report blanks furnished with the seed.

UNIVERSITY OF WYOMING.

Agricultural College Department.

WYOMING EXPERIMENT STATION,

LARAMIE, WYOMING.

BULLETIN NO. 37.

JUNE, 1898.

THE STOOLING OF GRAINS.

BY B. O. BUFFUM.

Bulletins will be sent free upon request. Address: Director Experiment Station, Laramie, Wyo.

Wyoming Agricultural Experiment Station.

UNIVERSITY OF WYOMING.

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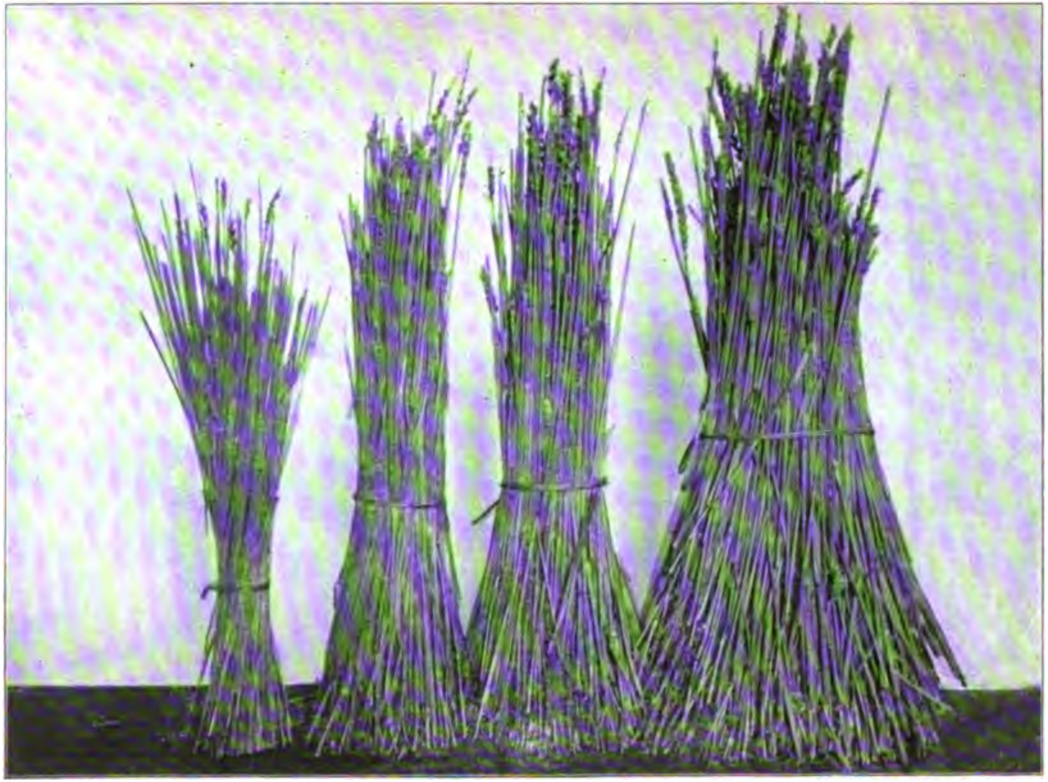

Stools 1 inch, 2 inches, 4 inches, and 12 inches apart.

CHILI WHEAT.

Each bundle shows straws produced by 50 seeds.

THE STOOLING OF GRAINS.

B. C. BUFFUM.

We believe the growing of small grains will always constitute an important part of general farm practice under irrigation in our state.

The average altitude for the state is placed at 6,000 feet. The climate is arid and the consequent lack of moisture and clouds in our rarefied atmosphere produces cool nights and comparatively short seasons. In any except our lower altitudes these conditions make the production of corn either impossible or unprofitable. When properly handled, wheat, oats, and barley are our most remunerative cereal crops. In addition to their more common uses, these grains will form the basis of our food rations for live stock. It may be expected therefore that the shortening of the open range along with the development of a more general agriculture and the increase of home feeding will tend to make the production of small grains of greater rather than of less importance,

The soils, altitude, and climatic conditions differ greatly in our somewhat widely separated agricultural sections and the camparative effects of these variations, in the natural order of things upon our staple crops are of importance in determining the best methods of culture to be pursued. We believed our experience in growing small grains indicated that heavier seeding was reqnired at high altitudes, other conditions being equal, than at low ones. Is it true that 120 pounds of seed per acre will produce a heavier and better crop of oats than half that amount and if so why is it true? The first object then of the experiments reported in the following pages was to study the effects of the different conditions in our state upon the life history of the plants themselves which would indicate in a general way differences in methods of treatment necessary to produce maximum yields.

In looking over our station literature we find but little data upon the tillering of grains and the conditions which change, one way or another, this important function.* A dozen years ago Prof. A. E. Blount, then with the Colorado station began advocating thin sowing in the west. He says "This habit of stooling in wheat, rye, barley, and oats should in all such plants be respected." He thought a bushel of good seed wheat sown evenly over an acre of good soil in good condition would be about twice too thick.†

Quite extensive investigations of different amounts of seed per acre of wheat, oats, and barley have been reported by several of the Experiment Stations in other states. Those in Indiana, Illinois, Ohio, Kansas, and other humid states indicate that heavy seeding is much better than light. We should bear in mind the fact however that results of this kind obtained in humid states under rainfall and the great difference in soil conditions are not applicable to our agricultural practice under the conditions prevailing in the arid region. The work in adjoining arid states would be of more value to us. In Nevada about 70 pounds of wheat per acre has given the best results, and in Colorado even less than this amount has been advocated.‡

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*Ala. Sta. Bul. 2 shows that the number of heads per stool produced by wheat increases with depth of planting. Kans. Sta. Bul. 20 shows some variation in number of stalks per plant in different varieties of oats, and Bul, 59 gives rate of seeding of wheat and number of stalks in 20 feet of row which shows a large increase in number of stalks as less seed is used down to one-half bushel per acre.

†Colo. Sta. Bul. No. 2, pp. 11-12

‡I give a list of the Station bulletins reporting different amounts of seed per acre which have come to my notice Wheat -Ala. Sta. Bul. No. 2; Ind. Sta. Bul. 27, 32, 41, 45, 56, 61; Ohio Sta. Bul. vol. 2, No 5; Ill. Sta. Bul. No. 11; Ky. Sta. Bul. No. 35, 42; Ill. Sta. Bul. 22, 34; Kans. Sta. Bul. 33, 50, 71; N. Dak. Sta. Bul. No. 10; Nev. Sta. Bul. No. 27 and Annual Rept., 1895; Oklahoma Sta. Bul. No. 28; Colo. Sta. Bul. No. 2. Oats—Colo. Sta. Bul. No. 2; Ill. Sta. Bul. No. 7, 19, 23, 41; Ohio Sta. Bul. vol. 3, No. 3, vol. 5, No. 1, and Bul. No. 57; Kans. Sta. Bul. No. 29, 42, 54, 63; Ind. Sta. Bul. No. 50, 55; Minn. Sta. Bul. No. 40. Barley.—N. Dak. Sta. Bul. No. 11; Colo. Sta. Bul. No. 2, 30, 40.

STOOLING EXPERIMENTS.

GENERAL CONCLUSIONS.

1. The number of mature heads produced by each seed of wheat, oats, or barley varies greatly with the locality, season, and distance apart seeds are planted.

2. The number of heads and the amount of grain produced by each seed increases rapidly with the greater amount of room accorded each.

3. When planted wide distances apart the straw is shorter than when thickly planted but, on account of the greater number of adventitious stems produced and the larger and more numerous leaves, there is more straw in proportion to the amount of grain where there is plenty of room.

4. Where given too much room many more stems are produced than will mature heads. On account of the continuous growth from the crown of the stool during the summer the grain is late in maturing, does not fill well, and, as a whole produces light, inferior grain.

5. Larger heads are produced upon grain planted more than one inch apart though all the heads may not be as uniform in size. The number of seeds in the largest heads produced increases rapidly with increased distances between plants.

6. While more grain will be produced by each seed when planted at greater distances than one inch apart the actual amount of grain will be less for the area of land used. Therefore seeding so thinly that there will be less than one plant for each inch of drill row decreases the amount of grain per acre rather than increases it. A study of our experiments seems to indicate that in farm practice sowing seed so plants will be secured about one inch apart

in the drill will produce largest yields per acre of wheat or barley but that oats should probably be planted a little thicker than this.

7. Wheat weighing sixty-one pounds per bushel had about 770 grains per ounce. Should 80 per cent of this grow, seventy-eight pounds sown evenly on an acre in drills eight inches apart would secure an average of one plant in each inch length of drill. Barley which weighed fifty-three pounds per bushel contained 700 grains per ounce, and, estimating 80 per cent germinating power, sown as indicated for wheat, it would take eighty-six pounds of seed per acre to secure a plant in each length of drill. Oats weighing forty pounds per bushel contained 980 seeds in an ounce. If 80 per cent of them grew when sown as above it would take sixty-one pounds per acre to secure a plant in each inch of row.

8. At Laramie in 1897 fifty and seventy pounds of wheat per acre gave as large yields as greater amounts but one hundred pounds per acre gave an equally large yield while the grain weighed more per bushel and ripened earlier. There was little difference in yields between barley plats sown at the rate of thirty or forty pounds per acre and those sown heavier but the grain was better and ripened earlier on plats with heavier seeding. Oats gave the heaviest yield when seeded at the rate of sixty pounds per acre. The grains were sown late and the season was short. The thinly seeded plats of wheat were frosted before the grain was fully ripe.

9. At Sheridan in 1897 the best results were obtained with wheat sown at the rate of sixty to seventy pounds per acre, with barley sown at the rate of from seventy to eighty pounds per acre, and with oats sown at the rate of from eighty to one hundred pounds per acre.

10 When grain is planted late or where the season

is short from natural causes thicker seeding is required than where the season is long.

11. In addition to the importance of thicker seeding at high altitudes to shorten time of ripening our experiments indicate that upon like soils and under similar climatic conditions wheat, oats, and barley actually produce less mature heads and less grain with increase of altitude.

12. Grain under irrigation produces more mature heads per stool and more grain than where raised without irrigation.

13. An average of the number of heads produced by fifty seeds grown at different distances apart in five localities of the state show that barley has the greatest tillering power, wheat second, and oats third.

14. A like comparison of the yields of grain produced from fifty seeds upon the same amount of land shows that barley produces the largest yield of grain, oats second, and wheat third.

15. The amount of grain produced with different amounts of seed per acre varies in different seasons On account of increased tillering, light seeding (from 30 to 50 pounds per acre) may produce as much grain as would a larger amount of seed but when more seed is sown the difference in weight of the grain per bushel along with shorter period of maturity and evenness in ripening may more than pay for the extra seed used.

ILLUSTRATIONS.

The plates here shown were made from photographs of the straw produced by fifty stools grown the different distances apart in 1897 at Laramie. As the oats in this experiment failed last season we are unable to compare them with the barley and wheat. The points given in paragraphs 3 and 4 of the conclusions are graphically brought out in these pictures. It will be noticed that the large bundles of straw from stools at greater distances apart look taller than the smaller bundles, while the grain in the plats stood almost the same height and the average length of the straw was actually shorter. They look longer in the pictures because in the large bundles it was impossible to keep the bottoms of the straws on the same level.

Before taking the photographs all the mature heads had been removed. The large increase in the number of immature heads, with increase of distance between the stools is apparent, especially in the wheat. Very few undeveloped heads were left in the straw from stools one inch apart. Attention is also called to the comparative fineness of the straw. With a great amount of room large, coarse straws are produced.

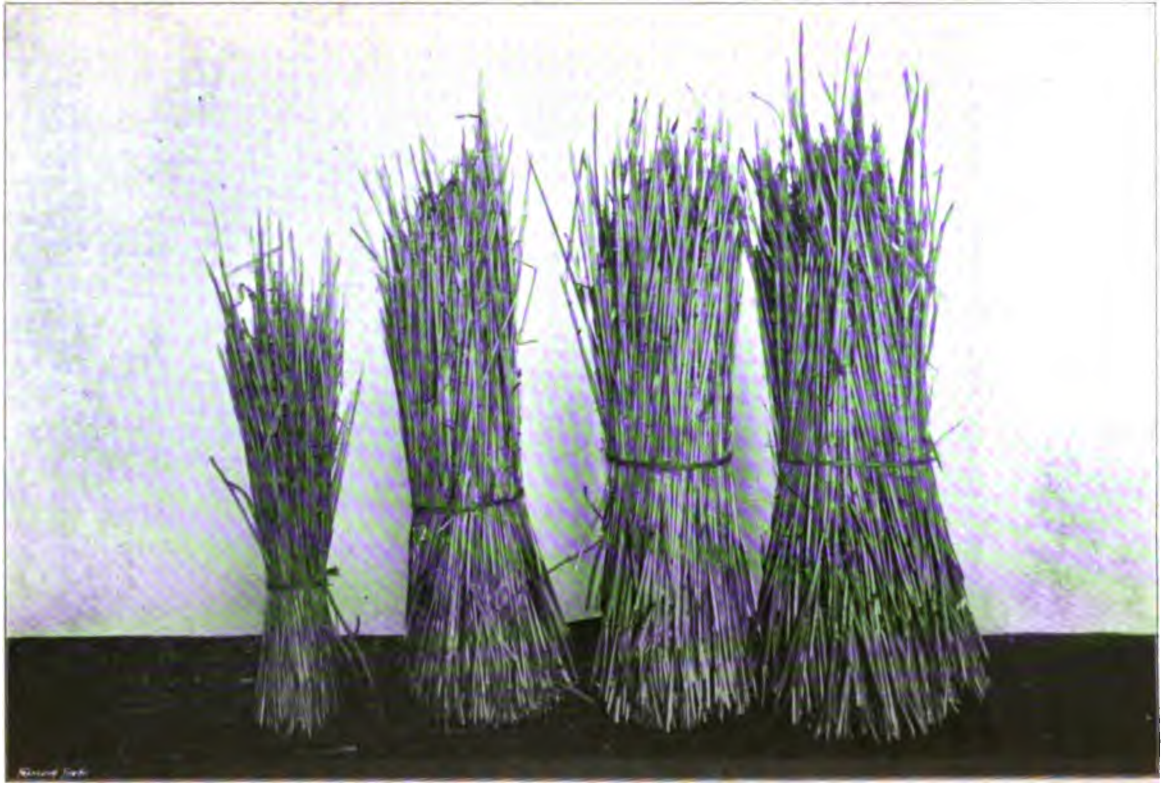
DETAILED REPORT OF EXPERIMENTS.

In 1896 experiments to determine the relative tillering of wheat, oats, and barley were made at five different places, viz: Laramie, Lander, Sheridan, Sundance, and Wheatland. At the close of the season, after having studied the data furnished from the different places it was decided to continue the observations through another season, changing the plan of and adding to the experiments somewhat before attempting to report results.

A brief outline of the instructions for the guidance of each superintendent in 1896, taken from the detailed plans of the season's work, is as follows:

"This experiment will take some time and careful attention but it is important to carry it out alike on each of the farms.

"Seed of wheat, oats, and barley have been hand selected. A smooth seed bed is to be prepared with a garden rake. It is to be free from lumps and mellow to a depth of at least three inches The rows are to be three feet apart.



Stools 1 inch, 2 inches, 4 inches, and 12 inches apart.

MANSHURY BARLEY.

Each bundle shows straw produced by 50 seeds.

UNIV. OF MICH.

All the seed is to be planted two inches deep and the wheat, oats, and barley are to be treated the same.

50 seeds are to be planted 1 inch apart.

50 seeds are to be planted 2 inches apart.

50 seeds are to be planted 4 inches apart.

25 seeds are to be planted 12 inches apart.

"Plenty of room is to be given between each planting so that there will be no danger of getting them mixed. The seeds of each planted are to be counted when they come up. The number of heads in each planting will be counted when the grain is in full head. All are to be treated alike. No hoeing or cultivating will be done near the plants but weeds growing there must be pulled. The following are instructions in regard to planting and the same method is to be followed in each case:

"Take a straight piece of 2x4 about six feet long. With an inch bit bore holes with their centers two inches apart making twenty-five of them. In these holes place pegs to fit, letting them project two inches from the 2x4 and taper each leaving a blunt point one-fourth to one-half inch across.

"When the seed bed is ready set the instrument in the row, press it down until the pegs are imbedded in the soil up to the 2x4, take it up and drop one seed in each hole. This will leave the seeds two inches apart and two inches deep For the seed that are to be one inch apart, after the seed has been planted two inches apart, set the pegs between the holes already planted and make the rest of the holes which when planted will leave the seeds one inch apart. For the seeds to be four inches apart drop one in every other hole.

"Proceed in this manner till all the seeds are planted. After the seeds are dropped and the holes filled turn the 2x4 on its side over the seed and step on it to firm the soil around the seed."

The seed was carefully selected from varieties grown at Laramie in 1895. In short the treatment of the plants throughout was as nearly the same at each place as possible.

In repeating the experiment in 1897 instead of fifty seeds of each of these grains one hundred seeds were planted. At the time the grain was far enough advanced to count up mature heads fifty stools were selected from the row, taking those where the fewest seeds failed to grow. This gives a record of the heads and grain produced from fifty seeds instead of a less number and eliminates a part of the error arising from greater distances allowed where the seeds did not come up. In addition to the stooling test in rows, small plats were planted with different amounts of seed per acre in order to give more light upon what to expect in actual field practice.

As investigations upon the Sundance and Wheatland farms were not continued in 1897 the experiments were only carried out at Laramie, Lander and Sheridan.

The seed for this experiment was selected and different amounts weighed out for each series of plats. The oats were treated for smut in the copper sulphate solution. They were left in too long and consequently failed to germinate when planted. At Sheridan the plats were replanted and excellent results finally obtained. It was so late before they could be replanted at Laramie that they did not ripen. However we are able to report an experiment with different amounts of oats per acre at this place, though as complete notes were not taken as in the special experiments with wheat and barley. This part of the experiment was to be conducted alike at the places mentioned. The general plan was to lay out small plats, 13x14 feet in size, planted in drills eight inches apart running diagonally across the plat. The plats were placed two feet apart each way. When about ready to harvest the edges of the plats were cut away in such a manner as to cross the drills diagonally leaving the grain standing in a space ten feet, eleven inches by ten feet which would amount to 1-400 of an acre. This grain from around the edges was cast out as it would probably be better developed on account of the nearness of the unused paths. The rest of the plants in the plat would be more nearly like those in a field. A lath frame made two feet square was then placed over the grain in an average part of the plat and all the heads standing within carefully counted. Full notes were to be kept including records of the total amount of straw and grain produced in each plat. On account of the serious illness of Mr. Meyer notes on this part of the experiment at Lander have not been received.

LARAMIE.

Table I gives the results of the stooling test for 1896. Only twenty-five seeds were planted at one foot distances, but in order to compare with other distances in the table all computations were made for fifty seeds. This has been done in all the experiments carried out in 1896. The column

TABLE I.—*Laramie, 1896.*

50 Seeds Planted.

GRAIN.	Distance Apart. Inches.	Highest Grain, ft.	Average Height, ft.	No. Stools Formed.	No. Stems Formed.	No. Mature Heads.	No. Heads Smutted.	No. Mature Heads Per Stool.	Weight of Straw, oz.	Weight of Grain, oz.	Weight of Grain Per Stool, oz.
Chili Wheat.	1	3.8	3.6	38	262	218	18	5.7	18.5	11.5	0.30
	2	4.0	3.7	47	390	330	12	7.0	31.0	21.0	0.45
	4	3.9	3.4	44	707	423	9	9.6	38.0	23.0	0.52
	12*	4.5	3.7	44	1516	936	40	21.3	134.0	51.0	1.16
White Wonder Oats.	1	4.5	4.0	44†	195	177	21	4.0†	32.0	11.0	0.25
	2	4.2	3.9	38	278	203	47	5.3	32.0	13.0	0.34
	4	4.3	4.0	46	473	431	29	9.4	56.5	27.5	0.60
	12*	4.3	4.0	42	816	716	52	17.0	176.0	54.0	1.29
Manshury Barley.	1	3.3	3.0	43†	293	277		6.4†	19.5	13.5	0.31†
	2	3.4	3.1	40†	422	412		10.3†	32.5	26.5	0.65†
	4	3.4	3.1	41	682	638		15.6	55.0	41.0	1.00
	12*	3.3	2.9	44	1304	1292		29.4	160.0	72.0	1.64

*25 seeds planted this distance apart. Computed as 50 seeds for comparison.
†Number of stools not counted at time of harvest.

giving the number of stools shows the number of seeds planted which reached maturity in each case. In the grains planted one and two inches apart it was difficult to determine accurately the number of stools at the time of harvest. The number of seeds which germinated and came up minus those which were known to have died or were eaten off gives the correct number of stools harvested. In several instances where it was impossible to count the ripe stools this note has been inserted in the tables.

We realize that using so small a number of seeds and such small plats is open to criticism in experimental work. However it is easier to control conditions on small plats and we think the remarkably uniform results obtained in these trials show that when carefully conducted, such experiments may result in data of much value, allowing conclusions to be drawn which could hardly be reached in any other way.

Table II gives data obtained in 1897. One hundred seeds were planted in each test and at the end of the season fifty stools were selected in that part of the row where fewest of the seeds failed to grow, and as all the data given

TABLE II.—*Laramie, 1897.*

100 seeds planted. 50 stools selected for record.

GRAIN.	Distance Apart, Inches.	Height of Grain, ft.	No. Stems Formed in 50 Stools.	Length of Heads, ft.	No. Mature Heads.	No. Mature Heads Per Stool.	Weight of Straw, oz.	Weight of Grain, oz.	Weight of Grain Per Stool, oz.	
Chili Wheat.	1	all was	233	0.33	154	3.08	20.5	7.5	0.15	Wheat Badly frosted.—Ripe Sept. 22.
	2	3.3 ft.	551	0.37	273	5.46	34.5	15.5	0.31	
	4	to	646	0.35	292	5.84	41.5	13.0	0.26	
	12	3.4 ft.	1453	0.40	486	9.72	96.0	18.5	0.37	
Manshury Barley.	1	2.75	243	0.35	224	4.48	14*	12.0	0.24	Ripe Sept. 3.
	2	3.2	601	0.35	240	4.80	30.5	37.5	0.75	
	4	2.9	720	0.35	543	10.86	40.0	41.0	0.82	
	12	2.9	1583	0.40	523	10.46	71.5	36.5	0.73	

*Estimated. Chaff from heads was not weighed.

in the different columns was obtained from the same number of stools they may be compared with more confidence. The results at hand which can be averaged for the two years are somewhat meager. Studies of the average number of heads per stool and the amount of grain per stool obtained in 1896 and 1897 show that the general result would not be changed. The only effect of averaging the two years work seems to be to smooth out the irregularities and with the material at hand we do not consider tables showing such averages of importance. These averages are indicated in the charts following the tables.

The grain was planted May 8th. The barley and wheat were both up May 20th. The oats failed to come up as the vitality of the seed was injured by treating for smut in too strong solution of copper sulphate. They were replanted on June 11th but it was so late that they did not mature. The wheat and barley were irrigated July 3rd and July 29th. Barley began to ripen September 3rd. Killing frost September 17th injured the wheat, more especially that which was planted so far apart that it was late in ripening. All the wheat fell below fifty-six pounds per bushel.

Tables III and IV report the special tests with different amounts of wheat and barley per acre. The barley

TABLE III.—*Chili Wheat, Different Amounts of Seed Per Acre, Laramie, 1897.*

SEED PER ACRE, LBS.	Height of Grain, ft.	Length of Heads, ft.	No. Mature Heads in 4 sq. ft.	Weight of Straw, oz.	Weight of Grain, oz.	Straw, per Acre, lbs.	Grain per Acre, lbs.	Weight per Bushel, lbs.
120	4.4	0.30	164	240	64	6000	1600	55.5
110	4.1	0.33	102	232	64	5800	1600	54.5
100	4.0	0.27	105	180	68	4500	1700	54.5
90	3.7	0.27	99	232	64	5800	1600	55.5
80	4.0	0.26	100	256	64	6400	1600	54.5
70	4.0	0.27	102	236	68	5900	1700	53.5
60	4.0	0.27	110	244	52	6100	1300	54.5
50	4.2	0 30	103	236	68	5900	1700	
40	4.6	0.30	112	258	54	6437	1200	52.0
30	4.3	0.30	96	192	48	4800	1200	52.5

was not cut as soon as ripe and heavy winds caused the plats which were the ripest to shatter out badly. Careful estimates of the per cent of the grain which was lost by shattering are given in the last column of the table.

TABLE IV.—*Manshury Barley, Different Amounts of Seed Per Acre, Laramie, 1897.*

SEED PER ACRE, LBS.	Height of Grain, ft.	Length of Heads, ft.	No. Mature Heads in 4 sq. ft.	Weight of Straw, oz.	Weight of Grain, oz.	Straw, Per Acre, lbs.	Grain, Per Acre, lbs.	Weight Per bu., lbs.	Remarks.
120. .	3.4	0.3	148	152	64	3800	1600	40.0	*15 per cent shattere
110. .	3.5	0.3	87	122	54	3050	1350	47.0	15 per cent shattere
100 . .	3.5	0.3	91	128	48	3200	1200	47.5	12 per cent shattere
90 . .	3.5	0.3	126	144	48	3600	1200	46.5	12 per cent shattere
80 . .	3.5	0.3	78	125	51	3125	1275	46.5	10 per cent shattere
70 . .	3.5	0.3	81	111	49	2775	1225	46.5	8 per cent shattere
60 . .	3.6	0.3	76	127	49	3175	1225	47.0	8 per cent shattere
50 . .	3.6	0.3	65	105	43	2625	1078	46.5	3 per cent shattere
40 . .	3.7	0.3	81	149	59	3725	1487	48.0	2 per cent shattere
30 . .	3.9	0.3+	106	132	60	3300	1500	45.5	1 per cent shattere

*Per cents estimated.

Table V reports a field test upon different amounts o oats per acre. Each plat contained one-twentieth of a acre. The grain was sown with a press drill. By mistak the seventy pound plat and the eighty pound plat were har vested together. The table gives the average amount o straw and grain for each of these plats.

TABLE V.—*Lincoln Oats, Different Amounts of Seed Per Acre, Laramie, 1897.*

One-twentieth acre plat used in each case, and grain planted with press drill. In this r spect being different from the barley and wheat.

SEED PER ACRE, LBS.	Yield Per Acre, Straw, lbs.	Yiel Per Acr Grai lbs
120	1778.6	102
110	1704.4	108
100	1199.2	103
90	1321.1	103
70 and 80*	1204.1	92
60	1567.1	117
50	1676.8	106
40†	2037.6	125

*The two plats planted at the rate of 70 and 80 pounds per acre respectively were ha vested together. The average yield is given.

†On outside near alfalfa.

The comparatively large yield from the plat sown at the rate of forty pounds per acre is due to the fact that it was next to a plat of alfalfa. The effect of alfalfa on the oats was quite noticeable and we do not think a comparison should be made between this and other plats. After cutting out this plat the results show the best yields from sixty pounds to the acre.

LANDER.

Table VI reports the results in 1896. Superintendent Meyer carried out the work in a most careful manner and furnished a most excellent report.

TABLE VI.—*Lander, 1896.*

50 seeds planted.

GRAIN.	Distance Apart, Inches.	No. Stools.	No. Mature Heads.	No. Smutted Heads.	No. Heads Per Stool.	Average No. Grains in Six Selected Heads.	Amount of Grain, oz.	Grain, Per Stool, oz.
Chili Wheat	1	37	354	7	9.75	67	20.0	0.54
	2	41	655	17	16.37	85	41.0	1.00
	4	44	931	26	21.75	88	70.0	1.59
	12*	36	690		19.16	113	60.0	1.67
White Wonder Oats.	1	44	295	22	7.20	99	25.0	0.57
	2	45	345	48	9.00	97	20.0	0.44
	4	45	584	33	13.71	118	100.0	2.22
	12*	32	628	92	22.50	141	94.0	2.94
Manshury Barley.	1	45	550	.....	12.22	56	31.0	0.69
	2	43	774	.....	18.00	66	53.5	1.24
	4	46	1616	.....	35.13	76	111.0	2.41
	12*	40	1466	.....	36.62	73	144.0	3.60

*25 seeds planted. Computed as fifty seeds for comparison.

The grains were planted May 13th and all were irrigated July 10th and August 13th. The wheat came up May 24th and 25th and was harvested September 18th. The largest number of heads in a stool of wheat was, 1 inch apart 18, 2 inches apart 45, 4 inches apart 43 and 12 inches apart 60. The White Wonder oats came up May 25th and were ripe September 7th. The largest number of heads in a stool was, 1 inch apart 13, 2 inches apart 15, 4 inches apart 26, 12 inches apart 43. The Manshury barley came up May 25th to 29th and was ripe September 4th. The stools growing one inch apart were so close that the heads from each separate stool could not be counted. The largest number from a single stool planted 2 inches apart was 47, 4 inches apart 97 and 12 inches apart 74.

Table VII reports the results in 1897. It will be noticed that only about half the number of heads were produced per stool and half as much grain as was obtained the previous season. The wheat was planted May 12th and came up May 22nd, irrigated July 1st and 29th and ripe August 30th. The greatest number of stalks per stool was, 1 inch apart 16, 2 inches apart 40, 4 inches apart 32 and 12 inches apart 56. The barley was planted May 12th, came up May 19th, was irrigated July 1st and 29th and was ripe August 15th. The largest number of heads to a stool was, 1 inch apart 17, 2 inches apart 27, 4 inches apart 38, and 12 inches apart 55.

TABLE VII.—*Lander, 1897.*

100 seeds planted. 50 stools selected for record.

GRAIN.	Distance Apart, Inches.	Height of Grain, ft.	No. Stems.	Length of Longest Heads Inches.	No. Mature Heads.	No. Heads Per Stool.	Weight of Straw, oz.	Weight of Grain, oz.	Weight of Grain per Stool, oz.
Chili Wheat.	1	3.0		4.0	241	4.8	17	12.5	0.25
	2	3.3	481	4.5	400	8.0	32	19.5	0.39
	4	3.3	686	4.7	630	12.6	83	32.7	0.65
	12	3.2	1240	6.0	1032	20.6	136	53.0	1.60
Manshury Barley.	1	2.3	327	4.2	297	5.9	18.5	17.0	0.34
	2	3.0	646	4.5	548	10.9	73.0	38.0	0.76
	4	2.5	765	4.2	555	11.1	81.5	42.5	0.85
	12	2.9	1743	5.0	1341	26.8	244.0	123.0	2.46

SHERIDAN.

The farming land around Sheridan produces large yields of wheat and is especially noted for the large yields of oats which have been obtained there. However, the stooling test in 1896 reported in Table VIII gave no startling results. It seemed to be an "off season" and a shortage of water for irrigation caused complaint. The superintendent, Mr. J. F. Lewis, kept excellent records and furnished good reports of the tests for both seasons. It should be stated that the distance between the rows was twenty-eight inches instead of three feet as at other places. With so much distance between the rows it is doubtful if this difference would modify the results in any material way. The wheat was planted April 25th, came up May 8th, irrigated June 12th, July 6th and 30th and was ripe August 11th. The notes state that some of the heads were blighted but the cause was not apparent. The grain planted twelve inches apart did not ripen evenly. The barley was planted, came up and was

TABLE VIII.—*Sheridan, 1896.*

50 seeds planted.

GRAIN.	Distance Apart, Inches.	Height of Grain, ft.	No. Stools.	No. Mature Heads.	No. Heads Smutted.	No. Heads Per Stool.	Weight of Grain, oz.	Weight of Grain per Stool, oz.
Chili Wheat.	1	2.5	37	184	.....	4.97	9.5	0.26
	2	2.7	46	316	.....	6.87	16.5	0.36
	4	3.0	46	402	.....	8.74	19.5	0.42
	12*	2.3	40	324	.....	8.10	22.0	0.55
White Wonder Oats.	1	2.8	46	224	32	4.87	24.0	0.52
	2		47	182	72	3.87	20.5	0.44
	4		50	287	47	5.74	36.0	0.72
	12*		46	374	108	8.13	36.0	0.78
Mansbury Barley	1	2.4	48	247	.....	5.14	24.0	0.50
	2	2.5	44	342	.....	7.77	28.0	0.64
	4		49	508	.....	10.37	48.0	0.98
	12*		44	730	.....	16.59	60.0	1.36

*25 seeds planted. Computed as 50 seeds.

irrigated on the same dates as the wheat. It was ripe August 1st. The notes state that the barley planted twelve inches apart did not ripen as evenly as that planted thicker. The oats were planted April 8th, came up May 10th and were irrigated on the same dates as the wheat. They were ripe August 10th. The seeds planted twelve inches apart produced shorter straw and less grain and ripened several days later than that planted thicker.

Table IX giving data for 1897 shows much better development and yields than were obtained in 1896. Planting was done May 5th. They were irrigated May 28th, June 15th, June 26th, July 7th, and July 30th. The wheat came up May 8th. That planted one inch apart was ripe August 20th, and that planted twelve inches apart was ripe August 28th with the exception of late stems around the outside of the stools. Straw was badly affected with rust, especially that which was thinly planted.

TABLE IX.—*Sheridan, 1897.*

100 seeds planted. 50 stools selected for record.

GRAIN.	Distance Apart, Inches	Height of Grain, ft.	No. of Stems formed in 50 stools.	Length of Heads, ft.	No. of Mature Heads.	No. of Heads per Stool.	Weight of Straw, oz.	Weight of Grain, oz.	Weight of Grain per Stool, oz.
Chili Wheat	1	3.2	375	0.33	303	6.0	70	48	0.96
	2	3.5	718	0.38	548	10.9	104	60	1.20
	4	3.2	650	0 38	572	11.4	103	94	1.88
	12	2.8	1050	0.38	750	15.0	152	82	1.64
Lincoln Oats (replanted)	1	3.2	372	0.83	325	6.5	56	35	0.70
	2	3.5	430	0.83	380	7.6	79	46	0.92
	4	3.3	484	0.87	447	8.9	85	71	1.42
	12	2.5	1036	. . .	734	14.7	120	52	1.04
Manshury Barley	1	3.2	509	0.25	480	9.6	56	44	0.88
	2	3.3	762	0.27	683	13.6	72	72	1.44
	4	2.3	981	0.21	801	16.0	88	85	1.70
	12	2.3	1295	0.21	900	18.0	121	87	1.74

The oats planted the first time did not grow and on May 25th they were replanted, the variety used being Lincoln. Those planted one inch apart were ripe August 20th and those planted twelve inches apart August 26th. The stools twelve inches apart rusted badly, causing light grain. The barley came up May 15th and was ripe August 4th, the straw being affected with rust. The superintendent writes "Rust seems to attack thin grain more than thick. Heretofore my observation has been the opposite. Thick grain gives more shade, allows less sunshine to enter and should be more liable to rust." I could not explain this unless as seems most probable it was due to the fact that the grain planted wide distances apart produced large succulent stems and a large growth of leaves near the ground, which remained green all summer, conditions which favor the growth of rust. I have noticed that winter grain planted in the spring would become badly rusted during the summer in the heavy green stools, while spring grain which had few leaves near the base of the stems would be almost or quite free from the disease. I may note here also that the number of smutted heads was greater upon the stools growing farther apart. This may be due to the fact that more heads are produced where more room is given and that the source of infection is with the seed from which the stool grows.

Tables X, XI and XII give the results of the special test of different amounts of seed per acre of wheat, barley and oats respectively. Each grain was treated the same except that the oats had to be replanted. The plats were placed upon old orchard ground which had been manured by mulch placed around the trees in winter. The trees had died and been removed. Mr. Lewis says it was a wonder to the visitors how he could raise such grain as the thirty pound plats produced. He says that the farmer who has not tried it does not realize what can be done upon our soils with manure and cultivation.

The wheat was planted May 4th, up May 8th, irrigated May 23rd, June 14th, 26th, July 7th and 30th. The grain

was ripe August 20th. The plat planted with 90 pounds of seed per acre was damaged by a ditch breaking and water soaking the ground. The barley plats were planted May 4th, came up May 12th, were irrigated May 23rd, June 15th, 26th, July 7th and 30th. The grain was ripe August 5th. Upon the thirty pound plat the heads seemed to ripen before the straw. The straw appeared green several days after the heads were fully ripe. The thickly sown plats were very ripe when cut, while those sown somewhat thinly were not fully ripe. The oat plats were resown on May 20th with Giant Side oats. They were irrigated and otherwise treated as the wheat and barley plats. The grain was ripe August 24th.

TABLE X.—*Chili Wheat. Different Amounts of Seed Per Acre. Sheridan, 1897.*

SEED PER ACRE, Pounds.	Height of Grain, ft.	Length of Heads, ft.	No. of Mature Heads in 4 sq. ft.	Weight of Straw, oz.	Weight of Grain, oz.	Straw per acre, lbs.	Grain per acre, lbs.
120	3.5	0.27	134	182	120	4800	3000
110	3.6	0.25	128	152	132	3800	3300
100	3.6	0.26	113	188	133	4700	3225
90	3.6	0.27	109	160	120	4000	3000
80	3.5	0.27	105	180	132	4500	3300
70	3.6	0.27	. . .	212	144	5300	3600
60	3.6	0.27	103	184	146	4600	3650
50	3.6	0.33	99	196	140	4900	3500
40	3.6	0.37	93	192	136	4800	3400
30	3.7	0.40	88	132	131	5800	3275

TABLE XI.—*Manshury Barley. Different Amounts of Seed Per Acre. Sheridan, 1897.*

SEED PER ACRE. Pounds.	Height of Grain, ft.	Length of Heads, ft.	No. of Mature Heads in 4 sq. ft.	Weight of Straw, oz.	Weight of Grain, oz.	Straw per acre, lbs.	Grain per acre, lbs.
120	3.2	0.25	138	123	120	3075	3225
110	3.3	0.27	134	114	134	2850	3350
100	3.3	0.27	130	140	156	3500	3900
90	3.5	0.25	128	140	156	3500	3900
80	3.3	0.25	124	140	156	3500	3900
70	3.3	0.25	121	160	161	4000	4025
60	3.4	0.27	120	126	146	3150	3650
50	3.4	0.29	105	164	140	4100	3500
40	3.2	0.27	103	123	134	3075	3250
30	3.3	0.27	102	100	116	2500	2900

TABLE XII.—*Giant Side Oats (Replanted). Different Amounts of Seed Per Acre. Sheridan, 1897.*

SEED PER ACRE, Pounds.	Height of Grain, ft.	Length of Heads, ft.	No. of Mature Heads in 4 sq. ft.	Weight of Straw, oz.	Weight of Grain, oz.	Straw per acre, lbs.	Grain per acre, lbs.
120	3.3	0.75	162	223	154	5575	3850
110	3.3	0.75	155	186	134	4650	3350
100	3.3	0.75	140	205	146	5125	3650
90	3.5	0.77	138	120	139	5500	3275
80	3.5	0.79	130	239	145	5975	3625
70	3.9	0.79	121	219	133	5537	3325
60	4.1	0.83	107	200	136	5000	3400
50	4.0	0.87	100	213	125	5725	3125
40	4.0	0.92	80	192	128	4800	3200
30	4.0	0.92	77	150	118	3730	2950

SUNDANCE.

The stooling experiment was only conducted one year at Sundance the results of which are given in Table XIII. The superintendent having this work in charge was Mr. A. E. Hoyt. This is the most humid section of the state and the only farming district in which crops are raised without

TABLE XIII.—*Sundance, 1896.*

50 seeds planted.

GRAIN.	Distance Apart, inches	No. of stools formed	No. of heads formed	No. of heads smutted	No. of heads per stool	Weight of Grain, oz.	Weight of Grain per stool, oz.
Chili Wheat	1	45	222	0	5.0	12	.27
	2	47	354	22	7.5	18	.38
	4	40	620	13	15.5	32	.80
	12*	38	876	50	23.0	56	1.47
White Wonder Oats	1	49	166	44	3.4	7	.14
	2	44	248	31	5.6	14	.32
	4	47	280	122	6.0	16	.34
	12*	46	520	68	11.3	64	1.39
Manshury Barley	1	42	212	. . .	5.0	12	.29
	2	45	276	. . .	6.1	20	.44
	4	45	538	. . .	11.9	40	.89
	12*	42	1436	. . .	34.2	88	2.09

*25 seeds planted this distance apart. Computed as 50 seeds for comparison.

irrigation. All the seeds were planted April 28th upon ground which had not been fertilized. The wheat came up May 7th and was ripe about August 12th. The barley came up May 7th and was ripe about August 6th. The oats came up the same date and were ripe August 10th. The plants from seeds planted greater distances apart were harvested later in each case than those planted close together.

WHEATLAND.

The work upon the Wheatland farm was carried out only one season. The superintendent, Mr. M. R. Johnston, took much interest in the stooling experiment. We report the results obtained in Table XIV. The wheat was planted May 7th when the ground was very dry. It was irrigated May 29th, June 9th, 29th and July 15th. It was harvested August 1st. Comparatively few stems formed in the wheat which did not mature heads. The barley was planted April 7th, irrigated May 29th, June 7th, 29th, and July 25th. It was harvested August 7th.

TABLE XIV.—*Wheatland, 1896.*

50 seeds planted.

GRAIN.	Distance Apart, Inches.	No. of Stools Formed.	No. of Stems Formed.	No. of Mature Heads.	No. of Heads Smutted.	No. of Mature Heads per Stool.	Weight of Straw, oz.	Weight of Grain, oz.	Weight of Grain per Stool, oz.
Chili Wheat	1	33	253	250	0	7.6	18	17	0.51
	2	45	450	446	0	9.9	19	32	0.71
	4	43	755	750	0	17.4	32	40	0.93
	12*	46	1030	1010	0	21.9	84	80	1.74
White Wonder Oats	1	38	339	260	56	6.8	25	20	0.53
	2	45	472	456	88	10.1	34	24	0.64
	4	48	640	520	106	10.8	35	49	1.02
	12*	44	1134	1004	60	22.8	94	100	2.27
Manshury Barley	1	22	263	230	0	10.4	13	16	0.73
	2	36	648	583	0	16.2	31	35	0.97
	4	42	848	796	0	18.9	55	49	1.17
	12*	34	1144	1060	0	31.2	122	84	2.47

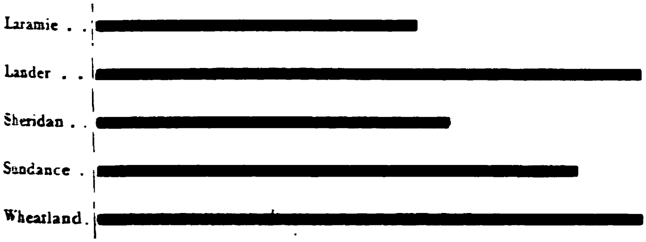
*25 seeds planted this distance apart. Computed as 50 seeds for comparison.

GRAPHIC PRESENTATION OF THE RESULTS GIVEN IN THE TABLES.

The lines represent averages of the number of heads and the amount of grain produced under all conditions in each locality. The results for two seasons at Laramie, Lander, and Sheridan have been averaged. With oats only one season's work was done except at Sheridan, where the results of two seasons are averaged. The lines for the different kinds of grain are drawn to the same scale so either the number of heads or the yields of each may be compared. As the same amount of land was used in each case the lines represent corresponding yields for equal areas.

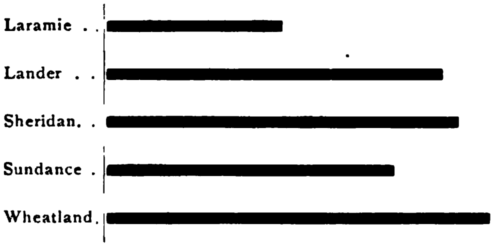
WHEAT.

Tillering shown by the average number of heads produced at each place. Wheatland and Sundance are for one season, other places represent averages for two seasons.



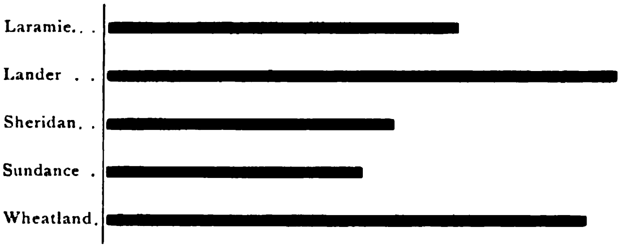
WHEAT.

Tillering shown by average yield of grain under all conditions. Wheatland and Sundance are for one season, other places represent averages for two seasons.



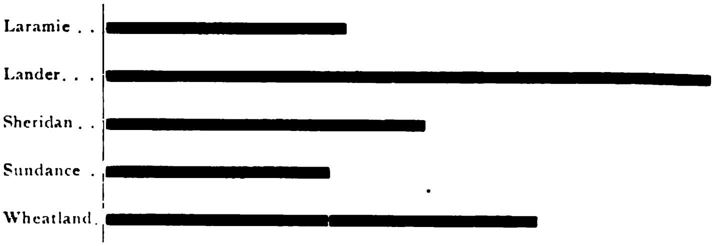
OATS.

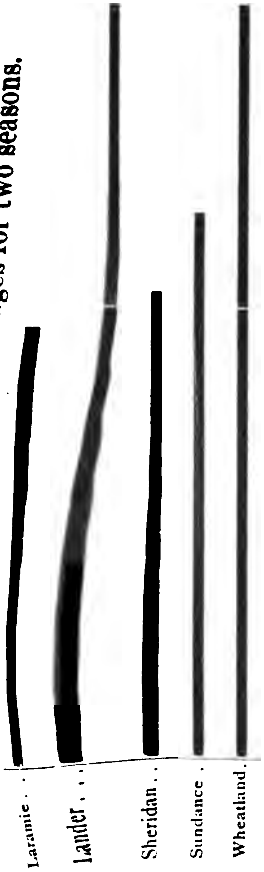
Tillering shown by the average number of heads produced under all conditions. At Sheridan average is for two seasons, other places for one season.



OATS.

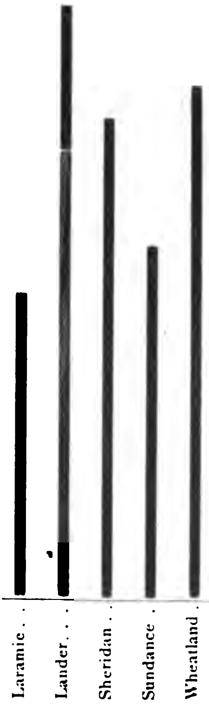
Tillering shown by the average yield of grain under all conditions. At Sheridan average is for two seasons, other places for one season.





BARLEY.

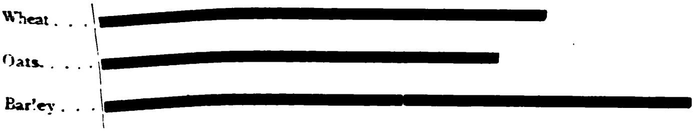
Tillering shown by the average number of heads produced under all conditions. Wheatland and Sundance for one season, other places represent averages for two seasons.



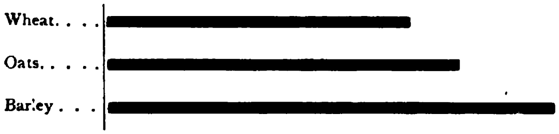
BARLEY.

Tillering shown by the average yield of grain under all conditions. Wheatland and Sundance for one season, other places represent averages for two seasons.

Comparative tillering of wheat, oats and barley as shown by the average number of heads produced under all conditions upon all the farms.



Comparative yields of wheat, oats and barley as shown by the average yield of each under all conditions and upon all the farms. We are often asked what grain to plant upon a small piece of ground to get the largest yield in any one season. This shows that under the average conditions in the state barley will produce the heaviest yield, i. e. the greatest weight of grain per acre, oats second and wheat third.



EFFECT OF ALTITUDE ON STOOLING OF GRAINS.

We have shown the difference in tillering power and yield of wheat, oats, and barley at each of the sub-farms. Because of the great difference in the natural conditions, especially of soil, in the different sections of the state it would be difficult to assign reasons for the difference in tillering and yields. Therefore a general comparison of these results merely indicates the relative amounts of grain which may be expected in each place.

No doubt the kind and condition of the soil has a most important influence, and grain raised upon a characteristic soil, as that at Sheridan for example, could not be compared with that grown upon an entirely different soil in order to assign difference in growth or yield to some other cause. Difference in fertility causes difference in number of heads produced by each seed.*

So far as we have been able to ascertain the conditions at Wheatland and Laramie in 1896 were very nearly the same except those due to difference in altitude and we venture to make a comparison of the stooling of grains at these places, believing that it indicates in a general way the influence of altitude upon their tillering capacity. Difference in conditions due to altitude are largely those appertaining to temperature and difference in air pressure At high altitudes the nights are colder and the seasons shorter than at low ones, variations which have an important effect on plant growth. The loss of moisture from plants through transpiration differs with change in intensity of light, change in temperature of the air, and the moisture in the air, and change in the pressure of the air itself.* Therefore differences in altitude along with the variations in climate would be expected to produce appreciable effects upon plant growth.

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*Recent experiments in Russia by D. N. Pryanishnikov and S. M. Kouznezov with barley show that the number of stems producing heads increased with the increase of nitrogen supplied in the form of sodium nitrate. Exp. Sta. Record, vol. IX, p. 741.

The altitude of the Laramie farm is approximately 7,200 feet while that at Wheatland is 4,700 feet, giving a difference of 2,500 feet.

The soils of the Laramie and Wheatland farms are almost identical.†

The two farms are located about sixty miles apart. Both have the same conditions of exposure, being out on the open plain away from the protection of surrounding hills and mountains. The climatic conditions other than those due to difference in altitude are much the same.

Table XV gives the data obtained in the stooling tests at Wheatland and Laramie in 1896. It will be noticed that more heads per stool and more grain were produced at the lower altitude. Taking averages of the heads and grain raised under all the conditions at the two places gives us with wheat a difference of 3.3 heads per stool in favor of Wheatland and 0. 27 oz. more of grain. With oats there were 3.7 more heads and .47 oz. more grain per stool at Wheatland With barley there were 3.8 more heads and

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*See Wyo. Sta. Bul. 15.

†See chemical analyses, Wyo. Sta. Bul 6, pp. 16 and 21; Geological Origin of the Soils, Wyo. Sta Bul. No. 14. pp. 105 and 116; Mechanical Analyses of the Soils, Wyo. Sta. Bul. 35, pp 165 and 173, and plates showing proportional amount of different sized soil particles, also chart, p. 183.

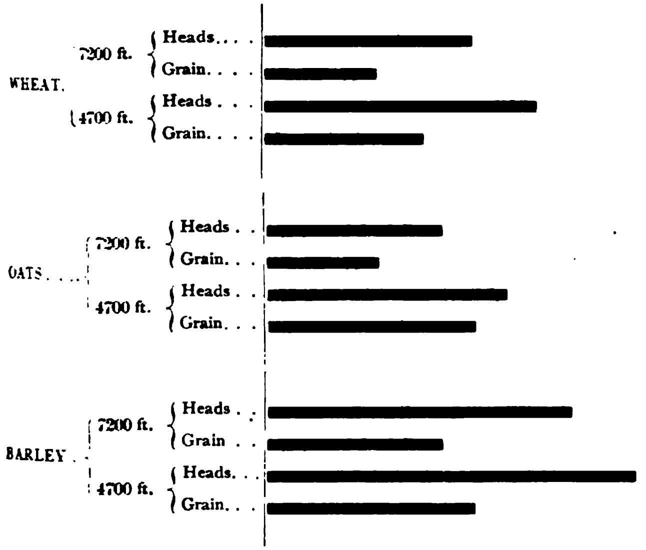
TABLE XV.

WHEAT.

	50 seeds 1 inch apart.					50 seeds 2 inches apart.					50 seeds 4 inches apart.					50 seeds 12 inches apart.				
	No. of Stools.	No. of Heads.	Heads per Stool.	Amount of Grain, oz.	Grain per Stool, oz.	No. of Stools.	No. of Heads.	Heads per Stool.	Amount of Grain, oz.	Grain per Stool, oz.	No. of Stools.	No. of Heads.	Heads per Stool.	Amount of Grain, oz.	Amount of Grain per Stool.	No. of Stools.	No. of Heads.	Heads per Stool.	Amount of Grain, oz.	Amount of Grain per Stool.
Laramie, 7200 ft. . .	38	218	5.7	11½	0.30	47	330	7.0	21	0.45	44	423	9.6	23	0.52	44	936	21.3	51	1.16
Wheatland, 4700 ft. .	33	259	7.6	17	0.51	45	446	9.9	32	0.71	43	750	17.4	24	0.56	46	1010	21.9	80	1.74
OATS.																				
Laramie, 7200 ft. . .	44*	177	4.0*	11	0.25*	38	203	5.3	13	0.34	46	431	9.4	27½	0.60	42	716	17.0	54	1.29
Wheatland, 4700 ft. .	38	260	6.8	20	0.53	45	456	10.1	24	0.53	48	520	10.8	49	1.02	44	1004	22.8	100	2.27
BARLEY.																				
Laramie, 7200 ft. . .	43*	277	6.4*	13½	0.31*	40*	412	10.3	20½	0.65*	41	638	15.6	30	0.95	44	1292	29.4	72	1.64
Wheatland, 4700 ft. .	22	230	10.4	16	0.73	36	583	16.2	35	0.97	42	796	18.9	49	1.17	34	1060	31.2	84	2.47

*Number of stools given from notes of the number of seeds which came up after deducting number of plants which died or were eaten off during the season. Other stools counted when harvested.

.44 oz. more grain per stool at Wheatland. These differences are shown graphically in the following chart in which one inch length of the heavy horizontal lines is allowed to represent ten heads per stool or one ounce of grain per stool.



It seems fair to assume that the difference exhibited in the stooling power of these grains may result directly or indirectly from the conditions due to the great difference in altitude.

EFFECT OF IRRIGATION ON STOOLING.

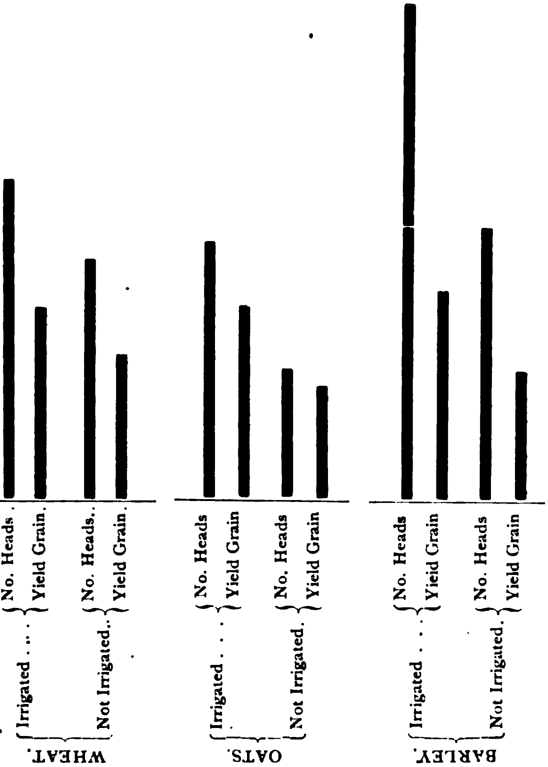
We are fortunate in being able to compare irrigated grain with that raised without irrigation in two places which are much alike in soil and general climatic conditions. As there may be conditions of which we are not aware that would produce important effects upon plant growth the results must be taken with some allowance, but we believe that this data illustrates the effect of irrigation in a way that is interesting and instructive and that some reliance can be placed on the general result.

It would be difficult to find two places one in a semi-humid and the other in an arid region which are more nearly alike in other important conditions than the Lander and Sundance farms. The altitude differs by about 1,000 feet, Lander being higher than Sundance. This difference in altitude probably has its effect upon the stooling of these grains, but according to our present information the stooling is diminished with increase of altitude. Therefore this difference rather helps out the validity of the results.

The average rainfall at Sundance exceeds that at Lander by about seven and three-fourths inches. The rainfall at Sundance is a little over twenty-one inches, and crops are raised without irrigation. The rainfall at Lander is about thirteen and one-half inches and irrigation is necessary for all crops. Both farms are surrounded by hills and mountains which protect them. While Lander is at a higher altitude, the mean annual temperature is also a little higher, being 43.7 degrees F., compared with 41.2 degrees at Sundance. (See Wyo. Sta. Bul. No. 27). The soils of the two places are very much alike. They are derived from the same geological horizons (see Wyo Sta. Bul. No. 14.) and are almost identical chemically and mechanically, (see Wyo. Sta. Buls. No. 16 pp. 17 and 20 and Bul. No. 35).

We compare the stooling in 1896 at the two places in Table XVI. At Lander the grains were irrigated twice, June 10th and August 13th. As before said the treatment of the soil, planting and treatment of the crops were the same at both places. With wheat there was a difference in favor of irrigated grain of four heads per stool and 0.47 oz. of grain per stool; with barley the difference was 6.5 heads per stool and 0.99 oz. per stool of grain.

With oats the difference was 11.2 heads per stool and 0.87 oz. grain per stool. The results can be illustrated in the following way allowing one inch of heavy horizontal line to represent 10 heads or one ounce of grain.



principal reason irrigation produces this effect
ns. As a rule the grain is not irrigated until the
ave formed. Up to this time there would be little
e in growth. Irrigation at the proper time supplies
ed moisture along with some plant food and makes
ant food available to such an extent that the tillers
ave formed are stimulated to the greatest pos-
wth causing a maximum number of heads to mature.
in which is not irrigated matures the number of
r which there is food and moisture leaving the re-
of the shoots undeveloped.

TABLE XVI.—*Wheat.*

	50 seeds 1 inch apart.					50 seeds 2 inches apart.					50 seeds 4 inches apart.					50 seeds 12 inches apart.				
	No. of Stools.	No. of Heads.	Heads per Stool.	Amount of Grain, oz.	Grain per Stool, oz.	No. of Stools.	No. of Heads.	Heads per Stool.	Amount of Grain, oz.	Grain per Stool, oz.	No. of Stools.	No. of Heads.	Heads per Stool.	Amount of Grain, oz.	Amount of Grain per Stool, oz.	No. of Stools.	No. of Heads.	Heads per Stool.	Amount of Grain, oz.	Amount of Grain per Stool, oz.
Irrigated.	37	361	9.7	20	0.54	41	672	16.4	41	1.00	44	957	21.7	70	1.59	36	690	19.2	60	1.67
Without Irrigation.	45	222	4.9	12	0.27	47	354	7.5	18	0.38	40	620	15.5	32	0.80	38	876	23.0	56	1.47
OATS.																				
Irrigated	44	317	7.2	25	0.57	45	393	8.7	20	0.44	45	617	13.7	100	2.22	32	720	22.5	94	2.94
Without Irrigation. .	49	166	3.4	7	0.14	44	248	5.6	14	0.32	47	280	5.9	16	0.34	46	520	11.3	64	1.39
BARLEY.																				
Irrigated	45	550	12.2	31	0.69	43	774	18.0	53.5	1.24	46	1616	35.1	111	2.41	40	1466	36.6	72	1.80
Without Irrigation .	42	212	5.0	12	0.28	45	276	6.1	20.0	0.44	45	538	11.9	40	0.89	42	1436	34.2	44	1.05

PRACTICAL HINTS ON GRAIN GROWING AT HIGH ALTITUDES.

ay be well here to speak of some general information the growing of small grains gleaned from several periments and observations. Farmers located be- 000 and 7,500 feet altitude will find that their con- necessitate some modifications of the general ral practice in vogue in other places. Our Station ly one situated at such an altitude and our farmers nate to have a Station here, supported by the gen- ernment, where such investigations can be made.

are often asked many of the following questions who are interested in growing wheat, oats and The answers are not merely guesses made upon principles, but are information obtained from seven years' actual practice. We have anticipated other s which have come to mind during the preparation lletin and which we are able to answer at this time.

it are the problems confronting the grower of ce- high altitudes?

t, on account of the short season, it is necessary early varieties and, second, it is difficult to prepare nd and sow the seed soon enough after the frost ficiently to allow the soil to be worked, where farm- ne on a large scale.

5)

Under these conditions can grain be grown with profit to the producer?

Yes, early varieties produce good crops of most excellent grain. Three years' experiments growing grain on a small scale at Laramie showed a profit of $8.88 per acre. Oats will bring even a better return, and barley succeeds better than either. Barley, when ground with other grain, is very valuable for feed, and our brewing barley is of the best quality. It requires but a short season. We have experienced no difficulty in ripening all varieties.

How can planting the grain early enough in the spring be accomplished?

By fall plowing. Our open falls give ample time for plowing after the crop is off. We recommend as deep plowing as possible and leaving the ground rough. In the spring harrow thoroughly before sowing the grain.

Will not the winter winds blow the loosened soil away?

One would think so, but we have had no difficulty of the kind. The ground is often so dry in the fall that it cannot be plowed. In such an event if water can be had the land should be irrigated thoroughly before plowing. Plowing in the fall retards evaporation during the winter and much of the water supplied by fall irrigation will be available to start the crop in the spring.

Will winter wheat succeed?

Not as a rule. At Laramie we have never been abl to make winter wheat stand the drouth of winter. Winte rye succeeds well.

n should grain be planted?

arly in the spring as the frost is out of the ground. ly varieties planted after the middle of May are frosted before they mature.

ou recommend any special method of sowing grain?

the best results are obtained when the press drill Ve use a shoe drill with wheels behind which press round the seed, insuring germination and growth. press drill will probably work better than the shoe od ground but we cannot speak of its use from our rience. Broadcasting and harrowing in the grain il of seed, secures comparatively poor results, and her out of date.

not using a heavy roller on land after sowing the n an ordinary hoe drill or other method do as well the press drill?

ller should never be used on our soils, where it is to save all the moisture possible. Leaving the mooth from rolling allows the most rapid loss of evaporation. If the roller is ever used to break for any other purpose, the surface should be immediately afterward with a harrow or cul-

not broadcasting the grain and plowing under se- ood results?

under the most favorable conditions. The grain sown so evenly, it is apt to be covered too deep are no defined drill rows which allow free entrance nd circulation of the air. However, plowing shal- er the grain is better than covering with the har-

What varieties do you recommend?

Any of the early standard varieties. We are growing all the varieties we can obtain with the hope that something may be found even better than the varieties that have already proven successful. Velvet Chaff or Blue Stem and the Fife wheats require a little longer season than we generally have here and they shell badly when ripe. Varieties of wheat which have succeeded best are, Defiance, White Russian, Amethyst, Australian Club, Chili, and such feeding sorts as Polish, Seven Head, and Pride of America.

A good feeding barley is Nepaul, which is both beardless and hulless. Good brewing sorts are, the Manshury, which is six-rowed, and Chevalier, Vermont Champion and Highland Chief in the two-rowed sorts. The Chevalier and Vermont Champion barleys drop their beards when the grain is ripe. The Chevalier is an especially fine variety but it must be cut at just the right time to prevent loss by shelling.

Varieties of bush oats seem to be earlier than varieties of side oats. The side oats, being late, grow the full length of the season and on this account are probably better to plant where they are intended to be cut for hay, as they produce a large amount of straw. The Bonanza seems to be especially fine for this purpose. Bush oats are recommended for the production of grain. Lincoln, Surprise, White Wonder and Clydesdale are excellent varieties.

Is it advisable to treat the seed before planting?

We have not been bothered to any extent with smut in barley, but wheat and oats should be treated unless it is known that the seed is clean. (For methods of treatment see Wyo. Sta. Bul. No. 21).

How many irrigations are necessary?

That depends upon so many conditions that no rule can ven. At low altitudes, as at Sheridan, the grain is often ated five times. On the Laramie plains good crops are ently secured with one or two irrigations. Sod land ires much more water than that which has been culti- l a number of years.

When should grain be harvested?

As a general rule when it is in the thick dough. With e head ripens before the straw. If left till the straw e the grain is apt to shell badly from winds. If har- d while the straw is still green the shocks should not ade too large as there might be some danger of the heating and spoiling.

Does it pay to put stable manure on land for grain?

Yes, if a light dressing can be put on at a moderate cost. season we found that putting on stable manure at the of twelve loads, of about one ton each, per acre increased ield of wheat from thirty-two to fifty bushels per acre. arge areas of land we believe there are rotations with minous crops which will keep up the soil fertility cheap- an by the use of manure.

What would be a good rotation for the Laramie plains?

A good four- year rotation would be: First year peas, d year grain, third year potatoes, and fourth year . A good six or seven year rotation would be: Alfal- ree years, fourth year grain, fifth year potatoes, sixth xth and seventh years grain. We find that growing for only one year makes a wonderful difference in the of grain, and alfalfa is a noted improver of the soil.

Should one of the cereals follow another on the same land?

Not if you wish to keep the seed clean and unmixed. All the seed which is left on the ground from one year's crop seems to grow the next season, so if grain is to be planted two years in succession on the same land, the same variety should be used.

Which of the grains is most apt to succeed upon land which begins to show alkali coming to the surface?

Rye will stand more alkali than other grains. In the field there is but little difference between the other grains, though wheat and barley seem to germinate in stronger alkali than oats. Upon land which is becoming affected by the rise of alkali to the surface, instead of planting grain of any kind, unless there is too much alkali, we would recommend planting alfalfa, which is a deep-rooted plant and which will keep the ground shaded a larger part of the time, preventing evaporation and the rapid accumulation of salts upon the surface.

What is the meaning of stooling and tillering as used in this bulletin?

As here used the two terms are synonymous. Tillering means the throwing out of additional stems or branches, often called "suckers," from the crown of the plant. This produces the stool, which consists of the total number of stems growing from a single seed.

NINTH ANNUAL REPORT

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GRICULTURAL COLLEGE

126

. . . OF THE . . .

UNIVERSITY OF WYOMING

. . . AND OF THE . . .

WYOMING
CULTURAL EXPERIMENT STATION

FOR THE FISCAL YEAR ENDING JUNE 30, 1899.

LARAMIE, WYO.,
THE REPUBLICAN BOOK AND JOB PRINT.
1899.

University of Wyoming.

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LETTER OF TRANSMITTAL.

Excellency,
on. De Forest Richards,
Governor of Wyoming,
Cheyenne, Wyoming.

President and Director I have the honor to present nth Annual Report of the Agricultural College and gricultural Experiment Station of Wyoming. This covers the work of the College and Station from 1898, to July 1, 1899.

pies will be sent also to all Agricultural Colleges, to cretary of the Treasury, to the Secretary of the In- and to the Secretary of Agriculture, in accordance ections 3 of Acts of Congress of August 30, 1890, and 2, 1887.

Respectfully submitted,

Elmer E. Smiley

sity of Wyoming,
une 30, 1899.

Faculty of the College of Agriculture.

ELMER E. SMILEY, D. D., President,
Professor of Political Science.
BURT C. BUFFUM, M. S.,
Professor of Agriculture and Horticulture.
AVEN NELSON, M. S., M. A.,
Professor of Biology.
HENRY MERZ, M. A.,
Professor of German and Social Science.
EDWIN E. SLOSSON, M. S.,
Professor of Chemistry.
WILBUR C. KNIGHT, M. A., F. G. S. A.,
Professor of Geology.
IRENE M. MORSE, M. A.,
Professor of French and History.
CHARLES B. RIDGAWAY, M. A.,
Professor of Mathematics and Physics.
LOUISE H. MOREY, B. A.,
Professor of English.

Professor of Military Science and Tactics.
WILLIAM F. GILKISON, B. S., M. E.,
Associate Professor of Drawing and Industrials.
JUNE E. DOWNEY, M. A.,
Instructor in English and Philosophy.
CHARLES H. FULTON, M. E.,
Assistant in Geology.
DANIEL C. ROYER, Q. T.,
Instructor in Bookkeeping.

NINTH ANNUAL REPORT

. . . OF THE. . .

ollege of Agriculture of the University of Wyoming.

I hereby submit the ninth annual report of the Col-
of Agriculture of Wyoming, in compliance with en-
ent of Congress. Following this report is a technical
r presented by Mr. Elias Nelson as a thesis for the M.
egree. While it reveals a large amount of research, yet
nnot be considered experimental and is therefore
ed with the Agricultural College report rather than
the report of the Experiment Station.

INCEPTION OF THE COLLEGE.

The first president of the University of Wyoming, when
tructing the various courses of the institution, in ac-
nce with the act of incorporation, planned for distinct
ols of agriculture and mechanic arts. These depart-
s did not obtain much growth until 1891. On the 10th
nuary of that year they were organized into separate
ges by an act of the Legislature of Wyoming, which
d the control of the appropriations from the Morrill
of Congress in the Board of Trustees of the State Uni-
ty. The Morrill Act, approved August 30, 1890, was
ded to grant an endowment for agricultural and me-
ical colleges in addition to that obtained by a land
on July 2, 1862.

PRESENT MANAGEMENT AND COURSE.

The Board of Trustees, whose names appear on a pre-
g page, have been changed since the last report by the
intment of Judge J. A. Riner and Hon. S. Conant Parks

in the place of Prof. J. O. Churchill and Hon. J. A. McAvo whose terms of office had expired; and by the election o Hon. Thomas T. Tynan as State Superintendent of Publi Instruction. The faculty of the College, with the positio held by each member, appears on another page. Wheneve a consolidation of classes has been possible, the professor o a subject has been employed as in the College of Libera Arts. Thus considerable expense has been saved to th state and an economical management effected.

The various courses in agriculture and mechanical engineering have been appended to this part of the repor and will be found to present as high a standard as those o any similar institution in the country. The model offere by the Committee on Courses of the American Associatio of Agricultural Colleges and Experiment Stations has bee closely followed.

EQUIPMENT.

The laboratory facilities of the Agricultural College a the same as those of the University and are very good i most branches of science; the comparatively small numbe of students in the higher classes gives opportunities for personal attention from instructors and the use of better apparatus than in most large institutions.

The Physical Laboratory is fitted with water, gas, a electricity, and accommodates students in sections of twenty-four at once. The method of conducting the laborato work in elementary classes is that which is sometim known as the "collective system." Under this method a are engaged on the same experiment at the same time, th allowing the teacher to instruct the whole class at once o difficult points, and still leaving him free to devote t greater portion of his time to assisting those who need particular attention. Each elementary student performs a series of experiments in accurate measurements and weigh n machines, and composition of forces; properties of ; the pendulum; heat; magnetism; electricity, testing istance and making of cells, etc. Advanced students he use of accurate instruments for electrical measure- motor, dynamo, and statical electrical machines, apparatus, phonograph, telephones, electrical heater, etc. The field work in surveying included in this deent covers the use of the Wye-level, compass, transit, lar attachment.

ne new equipment added to the Department of Physics the past year consists of the following apparatus: A s pendulum, an optical bench and accessories, a differ- galvanometer, a Waltenhafer pendulum, a Mack's nachine, a quadrant electrometer, an 18-light (16 canwer each) dynamo, a ½ horse power electrical motor, Tesla vibrator in addition to numerous smaller pieces demonstrations.

ne Geological Laboratory contains facilities for studyneralogy, geology, and paleontology. Students of miny determine in the first term some fifty minerals with ow-pipe and familiarize themselves with two hundred For advanced students in mineralogy there are two raphical microscopes, with rock sections and instru- for preparing the sections. The collection of rock ents for class use now numbers six hundred. The opities for field work in geology are fully described in partment statement. The paleontological collection g rapidly enlarged from Wyoming fields and already ample material for original work.

ne Chemical Laboratory has locked desks, provided as and water, for thirty-six students. Elementary ts perform about one hundred experiments, many of uantitative, and then make complete qualitative an- of twenty mixtures. Advanced students have all ary apparatus for difficult organic and inorganic preparations, quantitative analysis, including organic, gas, sugar, and electrolytic analysis, and determination of heat of combustion with the bomb calorimeter.

The Biological Laboratory is provided with sinks, gas, water, excellent compound and dissecting microscopes, microtomes, turntables, waterbaths, charts, models, photographic apparatus, and the necessary appliances for bacteriological work.

The Machine Shops are run as nearly as possible to correspond with actual manufacturing establishments. In the wood room each student has his own chest of tools for bench work and has the use of turning lathes, pattern maker's trimmer, mortising machine, pony planer, short jointer, boring machine, band saw, scroll saw, variety wood worker and circular saw with two cross cut and two rip saws. The iron room is provided with a 24 inch x 24 inch x 6 foot planer, a 25 inch back geared power feed drill press, a universal milling machine, a 14 inch x 6 foot engine lathe, a 1 inch x 6 foot engine lathe, a power back saw, a twist dril grinder, a power pipe-threading machine, a 14 inch sensitiv drill, and an emery grinder with two 14 inch wheels. Th foundry contains a Whiting cupola, 32 inch outside diameter lined down to a 23 inch, which has a capacity of meltin from 1,000 to 2,000 pounds of iron an hour. It is also provided with six 50 pound ladles, one 200 pound ladle, cor oven, flasks, riddles, bellows, and all tools necessary to ope ate a first-class foundry. There are also complete sets o piping tools for steam fitting and a forge for sharpening an tempering. Advanced classes have the use of an America Thompson Indicator and Arndt's Econometer with which t take indicator cards and test the efficiency of boilers.

MUSEUM.

The Agricultural Museum occupies a well-lighted roo on the third floor of the Main Building. The cases are larg lt of substantial oak. They contain a collection of ns of the cultivated crops and wild grasses of Wyo- With the collection of crops are the seeds of each in hibit bottles. The exhibit also includes some rare om Africa, Japan, and other foreign countries. The and forage crops raised on the Laramie Experiment ccupy one case. They are arranged in an artistic and contain heads of grain that for size and perfec- shape are rarely surpassed. The exhibition of wild consists of a portion of those sent to the World's 1893, which received the award of a medal and di- The fruits of our state are as yet not represented, e work has been done in reproducing the fruit in thus making it possible to keep them on exhibition anent form.

collection contained in this museum is instructive tudent and gives the stranger a good idea of what g is capable of in agriculture.

Herbarium now contains about 16,000 specimens. air working collection of the plants of the Western States, being rich in those of the Rocky Mountains ecially of Wyoming. A steady growth is maintained, ns of much value being added each year. It repre- e flora of Wyoming so far as known and is becom- nore and more interest to students who desire to special study of the plants of this range, especially it contains the types of many new species recently d. The herbarium is open to University students ers whose previous training is such as to enable them by its use.

NEW BUILDING.

ast legislature provided for an appropriation for a lding, which will probably be a Science Hall, and ude the Museum. This will relieve the pressure of the over-crowded laboratories, and will afford for the fi time an opportunity of exhibiting to the public the agric tural specimens, minerals and gigantic fossil saurians whi have hitherto been stored away for lack of room.

Departmental Statements.

The following is a detailed report of each departm of the College of Agriculture:

POLITICAL SCIENCE.

This department includes civic, public law, politi economy, and sociology. Its aim has been to cultivate in pendent thought and foster intelligent citizenship. Af the origin and growth of each subject has been investigat and the general principles have been acquired, the stud is required to apply the principles thus obtained to lead problems of the present day. Debates, public and priv form an important feature of the courses. The follow subjects are offered:

II. *Constitutional Law.* Cooley; Black. Examinat of cases; lectures; debates. [Elective for agricultural iors.]

III. *International Law.* Walker; Gallaudet; Wool Snow's Cases. Lectures; debates; theses. [Elective agricultural seniors.]

IV. *Political Economy.* Ely's Introduction; Wal Marshal; Gregory. Lectures; debates; theses. [Requ of agricultural and mechanical seniors.]

VII. *Comparative Government.* Wilson's The St Wenzel's Comparative View of Government; Bageh

Constitution; Helie's Les Constitutions de France; 's Sketch of the German Constitution; Bryce's n Commonwealth. Lectures; theses. [Elective for

SOCIAL SCIENCE.

aim of this department is to familiarize students history of social development and to encourage inion of the principles on which social progress de- After a thorough grounding in the fundamental re student is expected to observe the social phe- about him and to study the various problems in an lent manner. Inasmuch as sociology is a science t birth and its theories are constantly expanding, the class-work consists of lectures and theses. The g subjects are offered:

Principles of Sociology Small and Vincent; Gid- Kidd's Social Evolution. Lectures; debates; theses. e for agricultural seniors.]

Social Problems. Study of crime, suicide, insanity, m, charities, temperance, socialism, education, etc. on; theses. [Elective for agricultural seniors who en I and Philosophy IV.]

Social Philosophy. Lectures on social theories, old , and on the aims of society. Discussions; theses. e for agricultural seniors who have taken I and II.]

PHILOSOPHY.

work of this department is intended to furnish an ance with philosophic thought, to afford a training ethods of investigating philosophic phenomena, and the student with the latest methods of education. attention is given to physiological psychology. The this subject is illustrated by charts and models of

the brain and sense organs and by the introduction of va
ous experiments. In teaching logic more time than forme
is given to inductive reasoning, as a perfect knowledge
this form is especially helpful to scientific students and
those intending to do research work in philosophy.

I. *Psychology, Introductory.* James's Briefer Psych
ogy, or Titchener's Outlines of Psychology. Collate
Readings. The purpose of this course is to give the stud
insight into the principal psychological conceptions a
methods, and practice in simple psychological experimen
tion. [Required of agricultural juniors.]

II. *Psychology, Advanced.* Investigation of spec
topics. Reading, observation, experiment. [Elective
those students who have taken I; winter term; five tin
a week.]

III. *Logic.* Jevons-Hill's Elements of Logic as te
with Fowler, Bain, Sidgwick, and others for referen
Treatment of the proposition, immediate and mediate inf
ence, the hypothesis, arguments, and fallacies. Special
tention to the principles and methods of induction. [E
tive for agricultural seniors.]

IV. *Ethics.* Markenzie's Manual of Ethics, or M
head's Elements of Ethics. Lectures and discussions w
readings from Plato, Aristotle, Kant, Mill, Spencer,
others. A critical examination of different ethical theor
cheifly, Hedonism, ancient and modern; Rigorism; and E
lutionary Utilitarianism. [Elective for juniors and seni
spring term; five times a week.]

BIOLOGY.

The department of biology as at present organized
cludes botany, zoology and physiology.

Even in the introductory courses laboratory wor
made a prominent feature in order that from the first
dents may become self-reliant.

equipment of the department has been adequate mands made upon it, and as new necessities arise in on with the several courses, they will be supplied possible from the resources at command.

of the two rooms of the department is a convenient oom having, among its other equipments, a lantern roscope attachment. This enables the instructor to e on the screen by both lantern and microscope e subject under discussion.

laboratory is large and well lighted, and is fur- ith working tables and desks. The following sub- offered:

BOTANY.

, III. *General.* The purpose of this introductory to give a general view of the entire field. The work es from the simplest plants to the more specialized The first and second terms are devoted to the mor- and physiology of plants, and the third term to the and classification of phanerogams. [Required of ral freshmen.]

V. *Histology and Physiology.* A course in histology rimental physiology of the higher plants, together nsideration of some of the special problems of plant tion and morphology. [Elective for agricultural

Mycology. Fungi in general, but with special at- paid to those of economic importance. [Elective ultural seniors.]

ZOOLOGY.

, III. *General.* The aim is to acquaint the student main facts of animal structure, physiology, and tion by means of lectures, laboratory work on typi- al forms, and prescribed reading. It is a prerequi- he other courses in Zoology. [Required of agricul- homores.]

IV, V. *Comparative Anatomy of Vertebrates.* A stud of the principal problems connected with the successiv modification of the different organs in the several classes animals. [Elective for all who have taken I, II, and III.]

VI. *Microscopical Anatomy.* Microscopical techniqu methods of investigation, and the preparation of sections normal vertebrate tissues. [Elective for agricultural se iors.]

PHYSIOLOGY.

I. *Physiology and Hygiene.* This course assumes on th part of the student such general knowledge of the huma body as is provided in the grammar grades of our best publ schools. The course aims to review the more important su jects to consider the problems of hygiene that are of speci interest to all students. [Repuired of preparatory agricu tural students.]

AGRICULTURE.

The instruction in agriculture aims to give the stude the greatest possible knowledge of the science of agric tural practice in the time given. The larger part of the struction is by lectures. Where text-books are used, th are supplemented by lectures, keeping the student abre of the times.

Up to the senior year, as often as the other work permit, students are required to work in the green-house upon the agricultural grounds or experiment farm two ho each afternoon. As far as possible, the work is made to lustrate the branch being taught. The agricultural seum furnishes material with which to illustrate the stu of farm crops and the agricultural productions of the wo

In the work upon the farm and the instruction in class-room, the methods and results of the Experiment tion are always before the student. These will afford much general information regarding the practice of agri

is region, and will give him an insight into the way
ı important facts are deduced from the mass of
servations and notes. The following subjects are

'istory of Agriculture. Taught by lectures and refer-
ks, such as Goss's Principles of Plant Culture, and
s How Plants Grow, and How Plants Feed. A
line of the history of agriculture, followed by a
course in the principles of plant cultivation and
[Required of agricultural sophomores.]

Soils, Tillage, and Fertilizers. Taught by lectures
ence books, such as King's The Soil, and Storer's
ıre. [Required of agricultural sophomores.]

Farm Crops. Lectures. Planting, irrigating, har-
and marketing; laying out and improving farms;
nagement and farm accounts. The students' prac-
include setting up and running farm machinery,
and irrigating crops properly. [Required of agri-
sophomores.]

V. *Breeds of Live Stock.* Curtiss's Breeds of Live
'arfield's Cattle Breeding, and Miles' Stock Breed-
plemented by lectures and practice in judging by
points. [Required of agricultural juniors.]

Stock Feeding and Dairy Management. Armsby's
eeding, Henry's Cattle Feeding, and lectures. [Re-
agricultural juniors.]

HORTICULTURE.

instruction in this department aims to give the stu-
od general foundation in the science of gardening,
tivation, fruit raising, landscape and ornamental
g. During the spring term of one year, two hours
tory work each week in the multiplication of plants,
budding, and making cuttings are required. The
subjects are offered:

I. *Plant Forcing.* Study of green-houses and hot-bed and of the cultivation and propagation of vegetables a small fruits. Lectures. [Required of agricultural juniors

II. *Pomology.* Pruning, grafting, budding, cutting and orcharding. Lectures. [Required of agricultural j niors.]

III. *Landscape and Ornamental Gardening.* Lectur [Elective for agricultural seniors.]

IV. *Thesis Work.* Pollination, cross fertilization, va ation, or other advanced subject. [Elective for agricultur seniors.]

ENTOMOLOGY.

This department aims to give the student an insig into insect life, and to afford some knowledge of econom entomology through the study of injurious insects and t means for their extermination. The following subjects a required.

I. *Elementary.* Packard's Entomology, with Comsto for reference. Lectures. [Required of Agricultural ju iors.]

II. *Economic Entomology.* Smith's Economic Entom ogy, supplemented by lectures. [Required of agricultu juniors.]

IRRIGATION.

The object of this department is to give a general i of the principles of irrigation practice and water measu ment.

I. *Principles.* Effects of water on soil and crops, a measurement of water. Wilson's Irrigation Engineeri Lectures, reference reading, and practical work. [Requi of agricultural juniors.]

CHEMISTRY.

: work of all courses in the department of chemistry
imental and inductive so far as consistent with the
ment of the necessary amount of general informa-
tudents are from the first encouraged to work inde-
ly on lines of investigation in which they are spe-
terested.

: department of chemistry occupies four rooms in
h end of the Main Building. One room contains the
al balances and the chemical reference library, the
s devoted to the experimental work of the Wyoming
tural Experiment Station, the third is a lecture room,
fourth and largest room is fitted up for the classes
tative and quantitative analysis. The department
quipped with apparatus for research and analytical
organic and inorganic chemistry. The following
are offered:

Elementary. Storer and Lindsay. The aim of
rse is to give students a knowledge of the laws
ical change, a practical familiarity with the
l elements and compounds, and skill in the manipu-
apparatus. [Required of agricultural and mechan-
omores.]

Qualitative Analysis. Caldwell's Qualitative Ana
Students acquire the ability to detect the ordi-
ds and bases in any substance. [Required of agri-
and mechanical sophomores.]

Quantitative Analysis. Caldwell and Fresenius.
simple gravimetric and volumetric determinations.
e for students who have taken III.]

Inorganic Preparations. Erdmann's Anleitung zur
ung chemischer Präparate. Preparation of a num-
fficult compounds and elements. [Open to students
e taken III; spring term; laboratory work ten hours

)

VII. *Organic Chemistry.* Remsen's Organic Chemistry. Lectures and recitations on the compounds of carbon. [Required of agricultural juniors; fall term; five times a week.]

VIII. *Organic Preparations.* Gatterman; Practical Methods in Organic Chemistry. [Open to students who have taken VII; winter term; laboratory work ten hours a week.]

XI. *Agricultural Chemistry.* The chemistry of plant growth, and the application of chemical principles to practical agriculture, with special reference to the problems o the arid region. [Required of agricultural juniors; winte term; lectures three hours and laboratory work four hour a week.]

XII. *Applied Chemistry.* Lectures on chemical processes and manufacturers not included in metallurgy, and o methods of analysis and control. Most attention is paid t subjects of practical importance in Wyoming; such as petroleum and its products; coal, gas, and coke; building ston and cements; alkalies and acids; beet sugar; glass; air an water supply. [Required of mechanical juniors.]

GEOLOGY.

Most of the instruction in this department is given b lectures, but text-books are used for reference together wit the latest geological reports.

The location of the Agricultural College is exceptionall advantageous for the study of geology. Only a few mil east of the Laramie mountains rise nearly 2,000 fe above the campus, while to the westward the Med cine Bow mountains rise 5,000 feet. Both of the mountain ranges are mineralized, and mining has been ca ried on for many years. They furnish rich fields for t student of structural and dynamical geology, as well as f those who wish to study almost new Archean exposur Flanking these ranges are Paleozoic, Mesozoic, and Cenoz rocks that have been exposed by the mountain making a

ıent erosion, so that a student may easily make him-
ıiliar with the entire series of Rocky Mountains sedi-
ỵ rocks. The working collections of rocks and fossils
lepartment are not large, but are well selected and
ˈeasing in size very rapidly. The collection of Meso-
ˈertebrates is very complete and the collection of Ju-
ertebrates is the second in size in the United States.
e who wish to study economic geology special induce-
an be offered, since ores of economic value are numer-
l are only a short distance away from the University.
ins are also well supplied with mines of coal and
ı of clay, gypsum, and building stones.

ː following list of books is used for reference and
rk in this department: LeConte, Dana, Geikie, Kay-
ɛ, Lapparent, Tarr, Zittel, and Nicholson and Ly-
The following subjects are offered:

Dynamical and Structural. Geological forces, con-
in which stratified rocks are found, and general to-
ıy. Lectures; Le Conte and Dana as texts. [Re-
ɔf agricultural juniors.]

Mineralogical. Elementary study of mineralogy, in
student is required to determine fifty species of com-
nerals with the blow-pipe. Lectures; Crosby and
s texts. [Required of agricultural juniors.]

Historical. Study of fossilized life associated with
d rocks, and methods of determining formations
sociated fossil life. Lectures; LeConte and Dana as
[Required of agricultural juniors.]

Economic. Study of the minerals of economic im-
ɛ and methods of preparing them for the market.
s; Kemp and Tarr as texts. [Elective for agricul-
niors.]

Paleontological. Elementary course in paleontology.
s; Nicholson and Lydekker as text. [Elective for
ural seniors.]

VI. *Advanced.* Course arranged to suit the needs of students. One week in the field. [Elective for agricultural seniors.]

HISTORY.

The purpose of the department of history is to create a taste for historical reading and give the ability to comprehend rightly the events of the times by applying the experience of the past to the conditions and problems of today. The aim is not the accumulation of a mass of facts and dates, but the acquisition of a right camprehension of great historical events.

Text-books are used, especially in the preparatory classes; but the study of the assigned lessons is supplemented by reading different authorities on the same subject and by lectures. The historical library has been greatly enlarged during the past year and is at the disposal of the students in this department. The following courses are offered:

I. *England.* Montgomery's English History. [Required of preparatory students.]

II, III. *Mediaeval and Modern.* Myer's Mediaeval and Modern History. [Required of preparatory students.]

IV. *Greece.* Myers' History of Greece; Guerber's Mythology. [Elective for agricultural seniors.]

V. *Rome.* Allen's History of Rome. [Elective for agricultural seniors.]

VI, VII, VII. *Middle Ages.* Thatcher and Schwill Lectures and supplementary reading. [Elective for agricultural seniors.]

ENGLISH.

The aim of the preparatory work in this department i
to teach the students to understand and use the English la

orrectly and to coultivate in them a taste for the best ire. A thorough mastery of English grammar is re- before entrance to the Preparatory Year.

student's work in literature is made to furnish the n as well as the material for the preparation of es- These essays are subject to criticism both in the class th the individual writers.

e formal study of rhetoric is designed to ground the in the principles of English composition and to cul- his literary sense by analytical study.

e work in oratory is of a practical character. An s made to secure reading that shall be intelligent, and forcible, and to develop spontaneous expression e mental side. The student meets the instructor per- for rehearsal and criticism.

e following subjects are open:

I, III. *Composition and Rhetoric.* Constant practice ng. Hill's Foundations of Rhetoric. Selections from owing American authors are read, and passages are zed: Irving, Bryant, Longfellow, Whittier, Lowell, . Supplementary reading. [Required of agricul- nd mechanical preparatory students; three terms; five week.]

I, VIII, IX. *Literary Masterpieces.* Reading, com- , memorizing selections. The books prescribed are: 's Palamon and Arcite; Pope's Translation of the ooks I, VI, XXII, XXIV; The Sir Roger de Coverly in the Spectator; Goldsmith's Vicar of Wakefield; Ivanhoe; DeQuincey's Flight of a Tartar Tibe; s Last of the Mohicans; Selections from Tennyson's f the King; Hawthorne's House of Seven Gables. red of agricultural freshmen; three terms; once a

XI, XII. *History of Literature.* History of English nerican literature. Selected reading; composition;

recitations. [Required of agricultural sophomores and mechanical juniors.]

XIII, XIV, XV. *English Poets.* Chaucer and Spenser Burns, Wordsworth, Coleridge, Byron, Keats, Shelley; Tennyson and Browning. Critical reading of selected poem with study of the literary art of the poets. Comparativ study. Papers on topics connected with works read. Reading by the professor with requisite comments. Special attention is paid to the grammar and pronunciation of Chaucer's works. [Required of agricultural sophomores; thre terms; three times a week.]

XIX, XX, XXI. *Oratory.* Study of selections from great English and American orators. Composition. Recitations and declamations which are subject to criticism by th professor and by the class. Every member of this class i required to deliver in public one original oration at the en of each term. [Required of agricultural and mechanica seniors; three terms; once a week.]

MATHEMATICS.

The instruction in mathematics aims to develop th powers of mental concentration, to give facility in attackin original problems, and ability to recognize the differenc between logical proof and presumptive evidence, and t form in the students the habit of expressing his ideas in co cise mathematical language.

All fundamental concepts are presented in as many di ferent forms as possible, with fullness of explanation ar variety of illustration, so that the student may thorough understand all the principles involved.

The following subjects are required:

I, II, II, IV. *Algebra.* Wentworth, Wells, Taylor. Charles Smith. Fundamental operations. Fractions a fractional equations, simultaneous equations of the fi

Problems involving two unknown numbers, simple minate equations, involution and evolution. Radical aginary expressions, quadratic equations, ratio and ion. [Required of preparatory students and fresh-

VI. *Plane Geometry.* Wells, Wentworth. Chauvenet, an and Smith. Much of the time is devoted to solv- inal propositions, and when time permits, some of the methods and the geometrical theory of proportion ght. [Required of freshmen.]

I. *Advanced Algebra.* Well's College Algebra. Pro- ns, binomial theorem, convergent and divergent undetermined coefficients, logarithms, permutations mbinations, summation of series, determinants, the- equations, solution of higher equations. [Required anical sophomores.]

. *Trigonometry.* Well's New Trigonometry. The de- ent of the general formulae and their application to ation of triangles, polygons, and original field prob- [Required of agricultural juniors and mechanical ores.]

Analytical Geometry. Wentworth's Analytical Ge- The analytical geometry of the straight line, circle, ic sections; including a general discussion of the equation of the second degree, and an introduction eometry of three dimensions. [Required of mechan- iors, elective for agricultural seiors.]

, XII. *Calculus.* Osborne's Calculus. Differentiation ions, successive differentiation, indeterminate forms, ment of functions in series, maxima and minima, ns of two or more variables, tangents, normals, otes, direction of curvature, singular points, curve , evolutes, envelopes, and order of contact. Integra- plication to geometry and mechanics, successive in- n, integration of rational fractions, integration by rationalization, by parts and by series, lengths and areas of plane curves, areas of surfaces of revolution, and volumes of solids. [Required of mechanical juniors, elective for agricultural seniors.]

PHYSICS.

The aims of this department are to cultivate in the student habits of thoughtful observation, intelligent and rapid manipulation, and to give him a general knowledge of natural phenomena. In all courses the subjects are studied from the experimental side, the student spending at least one-half of the time allotted to the work in the laboratory under the direct supervision of the professor in charge.

The following subjects are offered:

I, II, III. *Elementary.* Carhart and Chute's Elements of Physics; Allen's Laboratory Physics. The properties of matter; mechanics of solids and liquids. Heat, sound, and light. Magnetism and electricity. [Required of freshmen.]

IV, V, VI. *General.* Barker's Physics. Outlined experiments with reference to laboratory manuals. Physical quantities, kinematics, dynamics, work and energy, attraction and potential, and properties of matter. Energy of mass vibration, molecular kinetic energy, radiant energy Energy of aether-stress, energy of aether-vortices, energy of aether-flow, and the electromagnetic character of radiation [Required of mechanical juniors and elective for agricultural seniors.]

VII. *Electric Measurements.* Measurements of resistances, calibration of amperemeters and voltmeters, calculation of the electromotive force of batteries and dynamos magnetic determinations, heating effect of currents, etc [Elective for agricultural seniors.]

MECHANICS.

e aim of the instruction in this department is to give
dent a thorough insight into the general principles
ing prime movers and mechanical movements, and
ıtance with the methods in which these principles
applied and combined in order to produce the desired
n all branches of engineering. Instruction is also
ı subjects which are rather more technical than theo-
and the application of theory to practice is never
ht of. The work is fully illustrated by frequent ref-
to the engineering and mechanical equipment of the
ity and other available sources.

e following subjects are required of mechanical stu-

II. *Founding.* Lectures on core making, loam, dry
en sand moulding; cast iron; flasks, facing, finishing,
ɪoon preparing, charging, tapping out, and stopping
·upola. [Required of mechanical freshmen.]

Iron Working Machines. Joshua Rose's Complete
al Machinist. Study of the use and care of iron ma-
, particularly the lathe; speed of different parts;
utting, turning eccentrics, taps and dies; fitting con-
rods; pumps, etc. [Required of mechanical juniors;
n; five times a week.]

Elements of Mechanism. Stahl and Woods' Ele-
ʏ Mechanism. Study of the elementary principles
ing mechanical movements and the modes of com-
ting motion. [Required of mechanical juniors; win-
ı; five times a week.]

Steam Boilers. A Treatise on Steam Boilers, by
and Flather. A general study of the different forms
ern steam boilers, their construction, advantages,
advantages. [Required of mechanical seniors; fall
ve times a week.]

Steam Engines. The Steam Engine, by Holmes. The mechanism and principles brought into use in the design of the modern steam engine. Gidding's adjustable model for universal valve movements is used in the class room. Careful study is also made of working engines. [Required of mechanical seniors; fall term; five times a week.]

VII. *Steam Engine Indicators.* The Slide Valve, by Rose, and Hemenway's Steam Engine Indicators. As many different engines are tested as time will permit. [Required of mechanical seniors; winter term; five times a week.]

VIII. *Engineering Materials.* Merriman's Mechanics of Materials. Theory of resistance of different materials, and study of those principally used in engineering, especially brick, stone, timber, iron, and steel. [Required of mechanical seniors; winter term; five times a week.]

IX. *Hydraulics.* A Treatise on Hydraulics, by Merriman. The flow of water through tubes, in pipes, canals rivers, and over weirs; measurement of water power and pressure of flowing water. [Required of mechanical seniors; spring term; five times a week.]

X. *Thermodynamics of Gases.* A study of the properties of gases, saturated vapor, and superheated steam, and their application to the steam engine. [Elective for mechanical seniors; spring term; five times a week.]

DRAWING.

The aim of the department of drawing is to develop an quicken the ability of observation and to follow as closely a possible the line of work done in the practical draftin rooms of machine shops.

The following subjects are required:

I. *Freehand Drawing.* Drawing from models and copies, with which the department is well supplied. [Require of agricultural freshmen, and of mechanical preparatory students.]

II. *Freehand Drawing.* Sketching parts of machine

sed in instrumental drawing. [Required of agricul-
esmen, and of mechanical preparatory students.]
. *Use of Instruments.* A short course in straight and
lines and lettering. [Required of agricultural fresh-
d of mechanical freshmen.]
. *Geometrical Constructions.* Geometrical problems
instrumental drawing. [Required of mechanical
n.]
Descriptive Geometry. An elementary course in pro-
[Required of mechanical freshmen.]
, VII. *Instrumental Drawing.* Detailed copies of
machines. Drawing to scale of parts of machines
etches taken in the shops by the students. [Re-
of mechanical sophomores.]
II, IX. *Shades and Engineering Colors.* Drawing and
machines and parts of machines. [Required of me-
l sophomores and juniors.]
Parts of Machines. Designing gears, cams, and
machines which apply to the study of Mechanics II.
ed of mechanical juniors.]
Blue Prints. Tracing and making drawings to be
the shops. [Required of mechanical juniors.]
I. *Machine Designing.* Designing a boiler or some
machines; the design to be as original as possible.
ed of mechanical seniors.]
II. *Steam Engine Drawing.* This subject is to accom-
e work in Mechanics V and VI. [Required of me-
l seniors.]

INDUSTRIALS.

s department is intended to simplify mechanical en-
g by teaching practical work in connection with the
It aims also to present the practical side of produc-
running the machine shops as nearly as possible on
ciple of actual manufacturing establishments.

I, II. *Wood Working.* Lectures on the care and management of carpenters' tools; exercises in lining, planing, sawing, notching, splicing, mortising, and tenoning. Bench work in wood; exercises in dovetailing, framing, paneling, and special work for the department. [Required of agricultural and mechanical preparatory students.]

III. *Wood Turning.* Exercises in straight and curved turning, compound curves, etc. [Required of agricultural and mechanical preparatory students.]

IV. *Pattern Making.* A large variety of patterns, including parts of machines, are made for use in the foundry. [Required of mechanical freshmen.]

V, VI. *Foundry Practice.* Exercises in moulding, pouring, charging and managing the cupola. The castings obtained are used by the students in the machine room. [Required of mechanical freshmen.]

VII. *Iron Work.* Exercises in filing and chipping, and the use of the drill press. [Required of mechanical sophomores.]

VIII. *Iron Planing.* Exercises and special work. [Required of mechanical sophomores.]

IX. *The Engine Lathe.* An elementary course; tapering, screw cutting, etc. [Required of mechanical sophomores.]

X. *The Engine Lathe, Advanced.* Special work; turnin up parts of machines, and work for the department. [Required of mechanical juniors.]

XI. *Milling.* Exercises in milling, sawing, gear cutting, spiral cutting, and work on parts of machines. [Required of mechanical juniors.]

XII. *Engineering Laboratory.* Testing the efficiency o boilers, and inspection visits. [Required of mechanical juniors.]

XIII. *Engineering Laboratory.* Testing steam engine learning the principles and operation of the steam engin

or and rigging; inspection visits. [Required of me-
l seniors.]

V. *Shop Engineering.* General work in shop man-
t, lining shaftings, and setting machines; inspection
[Required of mechanical seniors.]

. *Experimental Laboratory.* A thesis is produced in
ion with experimental work. [Required of mech-
eniors.]

ecial subjects of experiment are arranged for those
ve taken the baccalaureate of science in mechanics
h to take graduate work.

MILITARY SCIENCE AND TACTICS.

department of Military Science and Tactics is es-
d in accordance with the requirements of an act of
s donating public lands to colleges, one of the con-
being that military tactics shall be taught. It is
e control of an officer of the regular army, detailed
Var Department for its duty, without any expense to
te, under the provisions of Section 1225, Revised
of the United States. One hundred and fifty
eld rifles (cadet pattern; similar to those used at
oint) and equipments, and canon and sabres for
and cavalry practice, are loaned to the college by
. Ordnance Department. An allowance of ammu-
annually supplied by the general government for
s of target practice. All students are required to
oughout the year. The cadet officers are appointed
ommandant of cadets, subject to the approval of the
t. The commissioned officers are usually selected
e senior class, the sergeants from the junior class,
corporals from the sophomore class, general merit
itary efficiency being the qualifications considered.
ides obtaining the excellent physical results which
ystematic and regular military training, the *morale*

of the students will thus be improved. The virtues of patriotism, honor, and truthfulness are cultivated, and habit of neatness, promptness, and obedience are insisted upon

The rules prescribed by the President of the Unite States for the government of officers of the army detailed a Professors of Military Science and Tactics require the following course of instruction:

1. The course of instruction shall be both practica and theoretical, and shall be so arranged as to occupy a least one hour per week for theoretical instruction, and a least two hours per week for practical instruction.

2. The practical course in infantry shall embrac small-arm target practice, and, as far as possible, all th movements prescribed by the drill regulations of the Unite States army applicable to a battalion. Instruction in arti lery shall embrace, as far as practicable, such portions c the United States drill regulations as pertain to the formation of detachments, manual of the piece, mechanical maneuvers, aiming drill, saber exercise, and target practic Instruction should also include the duty of sentinels, an where practicable, castrametation. Such instruction sha be given by the Professor of Military Science and Tactic personally, or under his immediate supervision.

3. Theoretical instruction shall be by recitations an lectures personally conducted and given by the Professo of Military Science and Tactics, and shall include, as far a practicable, a systematic and progressive course in the fo lowing subjects: The drill regulations of the United State army, the preparation of the usual reports and returns pe taining to a company, the organization and administratio of the United States army, and the elementary principl governing in the art of war.

The military department shall be subject to inspectio under the authority of the President of the United State such inspection shall be made, when practicable, near t the college year. The inspecting officer shall, upon ival at the institution, report to the President or lministrative officer in order to obtain from him the ry facilities for the performance of his duty. A copy eport of inspection will be furnished the President istitution by the War Department.

itary drill has become a feature of all the courses in versity and it is required that all students appear at l in uniform. Students are advised to come to the without specially providing themselves with new and to arrange to wear the cadet uniform habitually college.

cost of the uniform is about $18.00. The grade of including the cap, wears well and proves to be cal.

male students are expected to provide themselves iforms. It consists of a blouse, trousers, and cap, l after the West Point uniform, with raised gilt but-

COURSE IN MILITARY SCIENCE.

ctical.—Cadets are divided into two classes, First Year and Subsequent Year Cadets.

all cadets: Practical instruction comprises the schools of the soldier, squad, and company in normal and extended order (Infantry Drill Regulations), guard mounting and guard duty, gallery and range target practice.

Subsequent Year Cadets: In addition to the above comprises artillery drill, saber exercise, and military signaling with flag and heliograph.

oretical.—Cadets are divided into four classes. The winter term is especially devoted to this instruction, which includes the following:

st Year Cadets: Infantry Drill Regulations, includin the schools of the soldier, squad, and company, in normal and extended order.

ond Year Cadets: School of the battalion and ceremonies (Infantry Drill Regulations), and U. S. Ma ual of Guard Duty.

Freshman Class: "Elements of Military Scienc Pettit.

Sophomore Class: U. S. Army Regulations, must rolls and returns, etc., Military Law, and Sta Laws relating to the National Guard.

The corps of cadets has this year been divided into t companies, with the commandant acting as major. T number of young men in the drill has been seventy-seven.

THE LIBRARY.

The library, which is also the general reading room the University, is situated on the second floor, in the nor wing of the main building. This is a large, well- lighted a ventilated apartment. The college students use this roo during vacant hours from 8:30 a. m. to 12 m., and from 1 3:15 p. m.

The students at all times during the day, for five da in the week, have free access to all the books and perio cals. Three volumes may be taken by any one individu and kept from the shelves for a period of two weekes. Boo reserved at the instance of professors ac collateral readi for their courses are shelved in their respective rooms, a can be taken out only on application to such professors, w are responsible for them during the period of their reser tion.

The library contains 7,000 bound volumes, and in dition several thousand unbound bulletins and reports agricultural scientific subjects.

There have been added to the University library, d ing the fiscal year 1898-99, 800 bound volumes and 1, pamphlets, including Experiment Station bulletins and p lications from the Department of Agriculture at Washi ton, D. C.

e following agricultural papers and Wyoming news-
are sent to the University:

as—
ier.
nia—
and Horticulturist.
Call.
American Science.
lo—
ier.
Field and Farm.
—
Southern Cultivator.
—
ie Farmer.
ge Judd Farmer.
ier's Review.
Farmer's Magazine.
Elgin Dairy Report.
ation Age.
—
r Leaf.

Homestead.
—
er.
ky—
ndustrial American.
na—
er.
nd—
er.
ern State.
nore Weekly Sun.
husetts—
and Home.
hman.
Grange Home.
ican Cultivator.
England Farmer.
n—
ge Visitor.

Missouri—
National Dairyman.
Nebraska—
Western Resources.
New Hamsphire—
Mirror and Farmer.
New Mexico—
Southwestern Farm and Orchard.
New York—
American Agriculturist.
Rural New Yorker.
Sugar Trade Journal.
Ohio—
American Grange Bulletin.
Ontario—
Farmers' Advocate.
Pennsylvania—
Germantown Telegraph.
Public Ledger, daily.
Virginia—
Southern Planter.
The Progressive South.
Washington—
Northwest Mining Review.
Wisconsin—
Hoard's Dairyman.
State Papers—
Bill Barlow's Budget.
Boomerang.
Carbon County Journal.
Central Wyoming News.
Cheyenne Tribune.
Fremont County Gazette.
Laramie Times.
Newcastle News-Journal.
News-Register.
Otto Courier.
Rock Springs Independent
Rock Springs Miner.

Saratoga Lyre.
Saratoga Sun.
Sheridan Journal.
Sheridan Post.
Sun-Leader.
Wheatland World.
Wyoming Press.

The scientific and general periodicals taken by the brary and kept on the tablese of the reading room are:

Agricultural Science.
American Gardening.
American Geologist.
American Historical Review
American Journal of Mathematics.
American Journal of Science
American Machinist.
American Naturalist.
Arena.
Art Interchange.
Asa Gray.
Atlantic Monthly.
Auk.
Berichte der Deutschen Chemischen Gesellschaft,
Biologisches Central-Blatt.
Book News.
Botanical Gazette.
Bulletin of the Torrey Botanical Club.
Carpenter and Builder.
Cassier's Magazine.
Century.
Cosmopolitan.
Cumulative Index.
Die Garten-laube.
Education.
Educational Review.
Electrical World.
Engineering Magazine.
Engineering Record.
Erythea.
Etude.
Fern Bulletin.
Fliegende Blaetter.
Forum.
Garden and Forest.
Germania.
Great Round World.
Harper's Monthly.
Harper's Weekly.
Home Study.
Journal of the Society of Chemical Industry.
Journal of the American Chemical Society.
Journal of the British Chemical Society.
Kunkel's Musical Review.
Literary Digest.
Meehan's Magazine.
Metal Worker.
Microscope.
Microscopical Journal.
Mining and Scientific New
Monist.
Nation.
Nature.
North American Review.
Outlook.
Philosophical Review.
Photographic Times.
Physical Review.
Plant World.
Political Science Monthly
Popular Science Monthly.
Power.
Psychological Review.
Public Libraries.

rly Journal of Pure pplied Mathematics
of Reviews.
e
fic American and Supent.
er.
Sociology.
Studio.
St. Louis and Canadian Photographer.
Terrestrial Magnetism.
Young Men's Era.
Western Electrician.

e University now uses the Dewey Decimal Card Catasystem, and in addition to the regular cards has oming from the Department of Agriculture at Wash- containing a complete list of publications sent from partment and its several branches in connection with periment Station work.

TREASURER'S REPORT.

UNIVERSITY OF WYOMING.
AGRICULTURAL COLLEGE.

Laramie, Wyoming, June 30, 1899.

port of treasurer of said institution to the governor State of Wyoming of amount received under act of ss of August 30, 1890, in aid of College of Agricul- d the Mechanic Arts, and of the disbursements there- nd including June 30, 1899.

on hand July 1, 1898	$ 8,999.81
receipt of installment for 1898-'99, July 28, 1898	24,000.00
tal available for year ending June 30, 1899	$32,999.81

Disbursements thereof for and during the year ending June 30, 1899.

ure	$ 1,083.60	
c Arts	2,829.37	
Language	3,128.60	
atical Science	1,149.29	
or Physical Sciences	8,816.21	
ic Sciences	3,503.41	
otal expended during the year		$20,510.48
lance remaining unexpended July 1, 1899		$12,489.33

ereby certify that the above account is correct and d, together with the itemized account attached, truly nts the details of expenditures for the period and by titution named, and that said expenditures were applied only to instruction in agriculture, the mechanic arts, the English language, and the various branches of mathematical, physical, natural, and economic science, with special reference to their application in the industries of life and to the facilities for such instruction.

John C. Davis, Treasurer.

Courses of Study.

AGRICULTURAL COURSE.

For explanation of the Roman numerals, see departmental statements on preceding pages. The Arabic numerals indicate the number o hours a week. Where no numeral appears, 5 is understood. Two hour of laboratory, shop or field work are counted as equivalent to one hou of recitation or lecture.

PREPARATORY YEAR.

FALL TERM.	WINTER TERM.	SPRING TERM.
History, I.	History, II.	History, III.
English, I.	English, II.	English, III.
Mathematics, I.	Mathematics, II.	Mathematics, III.
Physiography, I.	Physiography, II.	Physiology, I.
Industrials, I.	Industrials, II.	Industrials, III.
	FRESHMAN YEAR.	
Physics, I.	Physics, II.	Physics, III.
Mathematics, IV.	Mathematics, V.	Mathematics, VI.
Drawing, I, 4.	Drawing, II, 4.	Drawing, III, 4.
German, I.	German, II.	German, III.
Botany, I, 4.	Botany, II, 4.	Botany, III, 4.
English, VII, 1.	English, VIII, 1.	English, IX, 1.
	SOPHOMORE YEAR.	
Zoology, I.	Zoology, II.	Zoology, III.
German, IV.	German, V.	German, VI.
Chemistry, I.	Chemistry, II.	Chemistry, III.
English, XIII, 3.	English, XIV, 3.	English, XV, 3.
Agriculture, I, 2.	Agriculture, II, 2.	Agriculture, III, 2.
	JUNIOR YEAR.	
Geology, I.	Geology, II.	Geology, III.
Entomology, I, 3.	Entomology, II, 3.	Horticulture, II, 3.
Philosophy, I.	Horticulture, I.	Mathematics, IX.
Agriculture, IV, 2.	Agriculture, V, 2.	Agriculture, VI, 2.
Chemistry, VII.	Chemistry, XI.	Meteorology, I, 2.
		Irrigation, I, 3.
	SENIOR YEAR.	
Political Science, IV.	English, XX, 1.	English, XXI, 1.
English, XIX, 1.	Elective, 15 hours.	Elective, 15 hours.
Elective, 10 hours.		

MECHANICAL COURSE.

r explanation of the Roman numerals, see departmental state-
on preceding pages. The Arabic numerals indicate the number of
week. Where no numeral appears, 5 is understood. Two hours
ratory, shop or field work are counted as equivalent to one hour
ation or lecture.

PREPARATORY YEAR.

LL TERM.	WINTER TERM.	SPRING TERM.
I. I. atics, I. , I. als, I.	History, II. English, II. Mathematics, II. Drawing, II. Industrials, II.	History, III. English, III. Mathematics, III. Civil Government. Industrials, III.

FRESHMAN YEAR.

I. atics, IV. , III. , or German,I. als, IV.	Physics, II. Mathematics, V. Drawing, IV, 3. Mechanics, I, 2. French, II, or German, II. Industrials, V.	Physics, III. Mathematics, VI. Drawing, V, 3. Mechanics, II, 2. French, III, or German, III. Industrials, VI.

SOPHOMORE YEAR.

, VI. IV, or Ger- V. ry, I. atics, VII. als, VII. ping.	Drawing, VII. French, V, or German, V. Chemistry, II. Mathematics, VIII. Industrials, VIII. Bookkeeping.	Drawing, VIII. French, VI, or German, VI. Chemistry, III. Mathematics, IX. Industrials, IX.

JUNIOR YEAR.

cs, III. atics, X. IV. , IX. als, X. X, 1.	Mechanics, IV. Mathematics, XI. Physics, V. Drawing, X. Industrials, XI. English, XI, 1.	Physiology and Hygiene. Mathematics, XII. Physics, VI. Drawing, XI. Industrials, XII. English, XII, 1.

SENIOR YEAR.

Science, IV. cs, V. cs, VI. XII. XIX, 1. ls, XIII.	Mechanics, VII. Mechanics, VIII, or Mathematics, XIII. Drawing, XIII. English, XX, 1. Industrials, XIV.	Mechanics, IX. Mechanics,X, or Mathematics, XIV. Thesis. English, XXI, 1. Industrials, XV.

UNIVERSITY OF WYOMING.

LARAMIE, WYOMING.

REPORT OF THE PRESIDENT OF SAID INSTITUTION TO THE SECRETARY OF THE INTERIOR AND THE SECRETARY OF AGRICULTURE, AS REQUIRED BY ACT OF CONGRESS OF AUGUST 30, 1890, IN AID OF COLLEGES OF AGRICULTURE AND THE MECHANIC ARTS.

RECEIPTS FOR AND DURING THE YEAR ENDING JUNE 30, 1899.

1.	Balance on hand July 1, 1898, over and above all indebtedness (excluding funded debt, if any)	$10,686.8
2.	State aid; (a) Income from endowment granted by state	
	(b) Appropriation for current expenses	7,581.4
	(c) Appropriations for building or for other special purposes	
3.	Federal aid; (a) Income from land grant, act of July 2, 1862	
	(b) Additional endowment, act of August 30, 1890	24,000.0
	(c) For experiment stations, act of March 2, 1887	15,000.0
4.	Fees and all other sources	950.8
	Total	$58,219.0

XPENDITURES FOR AND DURING THE YEAR ENDED JUNE 30, 1899.

necessarily a balance sheet as compared with Division II above.)

struction in the subjects specified in Sec. 1, act of August 30, 1890*	$21,508.00
struction in all other subjects, if any, not mentioned in Question 1 of this series	4,100.00
dministrative expenses (President's, Secretary's, Treasurer's Librarian's salary, clerical service, fuel, light, etc.)§	3,300.00
xperiment Station	15,470.90
Total	$44,378.90

PROPERTY, YEAR ENDED JUNE 30, 1890.

of all buildings, $111,540; of other equipment, $46,500.

of above property (an estimate only is expected) not used for instruction in the subjects specified in section 1 of act of August 30, 1890, Buildings (all used); of other equipment, $16,000.

number of acres, 396; acres under cultivation, 180; acres used for experiments, 180; value of farm lands, $10,600; amount of all endowment funds, none.

er of bound volumes, June 30, 1899, 7,000; pamphlets, 4,800.

FACULTY DURING THE YEAR ENDED JUNE 30, 1899.

lege of Agriculture and Mechanic Arts;

	Male.	Female.
a) Preparatory classes	10	3
b) Collegiate and special classes	10	3
c) Total, counting none twice	10	3
mber in all other departments (excepting duplicates	3	1
nber of staff of Experiment Station	6	1

---

he answer to this question will include not only the amount re-
under the act of August 30, 1890 ("Morrill Act"), but also all
s that are expended for the subjects specified in that act, irre-
of the character of the funds the amounts may be drawn from
tuition fees, or endowment, etc.)

may be convenient for many institutions to answer 2 and 3 as
stion. Cost of new buildings is given under Division I.

STUDENTS DURING THE YEAR ENDED JUNE 30, 1899.

1. Colleges of Agriculture and Mechanic Arts:

	Male.	Female.
(a) Preparatory classes	10	1
(b) Collegiate and special classes	15	0
(c) Post graduate courses	0	0
Total, counting none twice	25	1
2. Number in all other departments	51	65

3. Number of students that pursued courses in agriculture, 2; mechanical engineering, 15; electrical engineering, 0; mining engineering, 10; architecture, 0; household economy, 0; veterinary science, 0; military tactics, 76. (It is not expected tha the sum of these figures will equal the number of student given above.)

4. What degrees and how many of each kind were conferred i 1898-'99?

   On men, 3 (M. A., 1; B. S., 2.)

   On women, 3 (B. A., 3.)

5. What and how many honorary degrees were conferred in 1898 '99? None.

[Signed] ELMER E. SMILEY,
President.

REVISION

. . . OF THE . . .

tern North American Phloxes

BY

ELIAS NELSON, M. A.

TED AS A THESIS FOR THE MASTER'S DEGREE IN
BOTANICAL DEPARTMENT OF THE GRADUATE
CHOOL OF THE UNIVERSITY OF WYOMING
AND PUBLISHED AS A PART OF THE
NINTH REPORT OF THE WYOMING
AGRICULTURAL COLLEGE.

ISSUED JUNE 1, 1899.

LARAMIE, WYOMING :
1899.

A REVISION

. . . OF THE . . .

rn North American Species of the Genus Phlox.

ıe only comprehensive treatment of the Western
American Phloxes is found in Dr. Gray's Revision
th American Polemoniaceae,* which is almost identi-
eproduced in the Synoptical Flora. The eastern
s seem to have received more attention, and are ap-
ly not so difficult to discriminate as the western,
have long been in need of careful study. Several
s as constituted by Dr. Gray have been aggregates,
the case of *P. Douglasii* the greatest confusion has
led. The greater abundance of material, resulting
ecent collections in the west, has made it possible
mpt a more consistent disposition of such composite
s. Since some work has been done of late in this
it has been thought that it might be of value to sum-
our knowledge of the western Phloxes, as well as to
critical study of the same.

ıis revision has been prepared at the University of
ing, and is based principally on the collection of
from the herbarium of the Missouri Botanical Garden,
at in the herbarium of this university. Loan of speci-
has also been had from the leading herbaria of the
In all, about six hundred species have been exam-
For loan of herbarium specimens I am much in-
to Dr. Wm. Trelease; C. V. Piper, Washington Agri-
al College; Alice Eastwood, California Academy of

---

c. Am. Acad. 8: 253-258.

Sciences; C. S. Crandall, Agricultural College, Ft. Collins, Colo.; J. W. Blankinship, Agricultural College, Bozeman, Mont.; U. P. Hedrick, Utah Agricultural College; and Francis Ramely, University of Colorado. Specimens for the herbarium of the University of Wyoming have been secured from J. W. Blankinship; L. F. Henderson, University of Idaho; M. E. Jones, Salt Lake City, Utah, and J. M. Bates, Long Pine, Neb. My hearty thanks are also tendered to Dr. B. L. Robinson for his kindness in furnishing me with facts in regard to several questions of importance. Above all, I owe much to Prof. Aven Nelson, who has spared no pains to make this revision possible, and whose constant encouragement has been greatly appreciated.

With the exception of one species, *P. Siberica*, which is also found in the Arctic region of this continent, this genus is exclusively North American. Twelve species are found in eastern North America, while the western part has thirty-eight, only three of which extend as far east as Nebraska. About twelve of these thirty-eight are peculiar to the Rocky Mountain region, and six have Washington as their center of distribution. Of the latter, *P. linearifolia* merges into *P. longifolia* toward the east, and that in turn into *P. Stansburyi* further south. Similarly *P. speciosa*, belonging to the region drained by the Columbia River, is replaced by *P. occidentalis* in California and in Arizona by *P. Woodhousei*. *P. adsurgens* is a native of Oregon and northern California, and *P. dolicantha* and *P. Covillei* are found in Southern California. *P.tenuifolia* and *P.Woodhousei* are peculiar to Arizona. *P. canescens*, *P. austromontana* and *P. gladiformis* belong principally to the Great Basin, with Utah as their center of distribution. *P. nana* and *P. triovulata* are peculiar to New Mexico, and Texas is remarkable for having four species of annuals.

Descriptions have not been prepared of those species whose identity is well known, nor of those which have been tly named. Since the genus is not here treated of as ole, no attempt has been made to assign subgeneric s to the groups which this revision covers. *P. Richard-* of the Arctic sea-coast and *P. alyssifolia*[*] of Assiniboia ot included in the following synopsis, since specimens ese species have not been at hand.

KEY TO THE SPECIES.

RENNIALS; calyx teeth not setaceous-tipped.

nate-caespitose to loosely caespitose; the style usually much orter than the corolla tube and nearly always shorter than the lyx.

costal portions of the calyx not replicate.

Flowers solitary, the annual growth one-flowered.

Leaves beset with woolly cobwebby hairs.

Densely arachnoid-lanate; leaves scale-like, ovate to lanceolate, much imbricated and crowded.

Leaves usually 4-ranked; corolla tube about twice the length of the calyx. **P. bryoides.**

Leaves not quadrifarious; corolla tube not exceeding the calyx. **P. muscoides.**

. Sparsely arachnoid-lanate; leaves subulate, usually distinctly bisulcate, less crowded.

Corolla tube about twice the length of the calyx. **P. canescens.**

Corolla tube little if at all exceeding the calyx. **P. Hoodii.**

||Leaves not beset with woolly cobwebby hairs.

Leaves hispid-ciliate and often with short glandular-tipped hairs.

b. Leaves hispid-ciliate on the margins; the latter not noticeably thickened-cartilaginous.

Leaves oblong-linear, bisulcate, 5-6 mm. long. **P. condensata.**

---

reene, Pitt. 3 : 27 (1898).

Leaves lanceolate, oblong-linear or lance-linear, usually plane or somewhat grooved, 8-14 mm. long.
P. caespitosa.

bb. Surface of the leaves often hispid-ciliate as well as the margins; the latter thickened-cartilaginous.

Leaves crowded, oblong to ovate, 3-5 mm. long; flowers sessile. **P. Covillei.**

Stems 25-75 mm. high, the internodes longer than the leaves; in the variety minor the leaves are approximated and crowded and the flowers peduncled.
P. albomarginta.

aa. Sparsely lanate-ciliate on the calyx and usually at the base of the leaves.

b. Not glandular.

A pair of plane, oblong-linear leaves at each node with acerose ones in their axils; style nearly equalling the corrola tube. **P. diffusa.**

Loosely caespitose-spreading; leaves all acerose; style about half the length of the corolla tube.
P. Douglasii.

bb. Glandular.

Stems erect or ascending; these as well as the acerose leaves sparsely covered with short fine glandular-tipped hairs. **P. Piperi.**

aaa. Pubescent on the peduncles and calyx or entirely glabrous
P. multiflora.

‡‡Flowers not solitary, the annual stems 1-several flowered.

||Leaves with thickened cartilaginous margins.
P. albomarginata.

|| ||Leaves not with thickened cartilaginous margins.

Loosely caespitose-spreading; sparsely lanate-ciliate on the calyx and at the base of the leaves; the latter acerose. **P. Douglasii.**

Stems erect, from a rhizome; very sparsely lanate; leaves subulate, somewhat bisulcate, the larger ones often plane. **P. andicola.**

Very loosely caespitose-spreading with prostrate stems; pubescent, hirsute or glabrous, rarely glandular; leaves lanceolate or lance-linear, plane.
P. Kelseyi.

ercostal portions of the calyx replicate.

Canescent-pubescent or glabrate; corolla tube glabrous. **P. austromontana.**

Glandular throughout, corolla tube pubescent. **P. gladiformis**

sely tufted, suffrutescent or nearly herbaceous, with erect or ssurgent stems and usually distant leaves.

e long, equalling the corolla tube or at least longer than the vary or stigmas.

Corolla tube glabrous.

Style exceeding the calyx.

Glabrous or pubescent, but not glandular.

b. Flowers nodding. **P. cernua.**

bb. Flowers not nodding.

Glabrous or finely pubescent; leaves linear, 2-3 mm. wide. **P. longifolia.**

Roughish pubescent throughout; leaves thickish, 2-3 mm. wide. **P. Stansburyi**

Glabrous or somewhat roughish pubescent; leaves narrowly linear, 1-1.5 mm. wide. **P. linearifolia.**

a More or less glandular, at least above.

b. About 5 dm. high. **P. tenuifolia**

bb. Less than 2 dm. high.

c. Corolla tube less than twice the length of the calyx.

Viscid-pubescent above; leaves erect, narrowly linear, 1 mm. wide. **P. virida.**

Viscid-pubescent throughout; leaves linear, acuminate, erect, 2-4 mm. wide. **P. viscida**

Glandular-puberulent; leaves usually spreading, linear, acute or bluntish at apex, 1-2 mm. wide. **P. longifolia puberula.**

cc. Corolla tube twice the length of the calyx.

Roughish-pubescent throughout and glandular; leaves linear, thickish, 2-3 mm. wide. **P. Stansburyi.**

Leaves ovate, narrowly oblong or lanceolate. **P. Stansburyi brevifolia.**

ccc. Corolla tube 3-4 times the length of the calyx. **P. dolicantha.**

|| ||Style not exceeding the calyx.

Coarsely hirsute throughout; leaves thick and rigid, ovate to lanceolate, about 2 cm. long. P. hirsuta.

‡‡Corolla tube slightly pubescent.

Leaves ovate, thin and glabrous. P. adsurgens.

††Style not longer than the ovary or stigmas.

‡Ovules solitary in each cell.

||Upper leaves on flowering stems dilated at base.

Stems slender; leaves linear; flowers in lax corymbose clusters. P. speciosa.

Stems short and stout; leaves rigid, lanceolate; flowers in congested corymbose clusters. P. lanceolata.

|| ||Upper leaves on flowering stems not dilated at base.

1-3 dm. high; leaves lanceolate to linear, 3-5 cm. long. P. occidentalis.

5-10 cm. high; leaves oblong to oblong-linear, 1-4 cm. long. P. Woodhousei.

‡‡Ovules 2-3 in each cell.

Stems slender, usually simple; leaves narrow, 1-2 mm. wide. P. triovulata

Stems freely branched; leaves 3-4 mm. wide. P. nana.

2. ANNUALS; calyx teeth setaceous-tipped.

*Leaves of firm texture, nearly all opposite. P. aspera.

**Leaves thin, mostly alternate.

†Corolla tube pubescent, exceedingly the calyx.

Stems 1-4 dm. long; leaves broadest at base; corolla lobes about 1 cm. long. P. Drummondii.

Stems 5-10 cm. long; leaves rather narrow at base; corolla lobes about 6 mm. long. P. tenuis.

††Corolla tube glabrous, not exceeding the calyx. P. Roemeriana.

SYNOPSIS OF THE SPECIES.

vinate-caespitose or loosely caespitose perennials, often with
nual stems, several cm. high; leaves approximated and often
bricated, scarious-connate, the old ones marcescent; flowers
r short-peduncled, usually solitary; corolla tube somewhat
ear the base within (the hairs wanting apparently in P.
style more or less shorter than the corolla tube; ovules
in each cell.

ves more or less beset with woolly cobwebby hairs.

ves scale-like, ovate to lanceolate, much imbricated, rather
arachnoid-lanate.

OIDES Nutt. Pl. Gamb. in Journ. Acad. Nat. Sci.
ser. 2, 1:153 (1848). Gray, Proc. Am. Acad. 8:253.
Gray, Syn. Fl. 2:132.

m central Wyoming to Utah and Colorada. Type
; "dividing ridge of the Rocky Mountains" in south-
oming (about lat. 42 degrees).

e typical forms have strictly 4-ranked scale-like
but in luxuriant plants the leaves are much longer
quadrifarious character entirely lost. In such
approaches very near to *P. muscoides* from which
lways be separated by its longer corolla tube.

mens examined: Wyoming; Henry Engelmann, "Moun-
r Sweetwater" River, 1888; C. C. Parry, No. 230, High ground
eastern rim of Green R. Basin, alt. 7000 ft.," 1873; B. C. Buf-
per Creek, 1892; Aven Nelson, Nos. 67 (Laramie Hills, 1894),
ramie Plains, 1895, the usual form with corolla lobes 3 mm.
30a (Green River, 1897), 4313 (Laramie Hills, 1898) and
ter, 1898, corolla lobes 6 mm. long): Southern Utah; A. L.
. 5, 1874: Colorado; T. S. Brandegee, Canon City, 1871,
ngre de Cristo Mts., 1874.

P. MUSCOIDES Nutt., Journ. Acad. Phila. 8:42, t. 6, fi
2 (1834). Gray, Proc. Am. Acad. 8:253. Gray, Sy
Fl. 2:132.

Type locality; "Rocky Mountains at the sources of th
Missouri River," western Montana.

Specimens examined: Montana; Mrs. C. H. Moore, Butte, 188
F. D. Kelsey, "Very abundant in Deer Lodge Co. N. E. of Helena
1891; W. T. Shaw, Deer Lodge, Bozeman, 1892.

‡‡Leaves less crowded, subulate, usually distinctly bisulcat
sparsely arachnoid-lanate, or with only a few hairs at base.

P. CANESCENS T. & G., Pacif. R. Rep. 2:122, t. 6 (1855).

Densely caespitose; lanate and somewhat canescent,
least when young; leaves subulate, pungent, somewh
granular-roughened, at length recurved-spreading, 6-10 m
long; corolla white (tube "yellow"), the tube somewh
hairy at base within, twice the length of the calyx
nearly so, the lobes broadly obovate to rotund, usually e
tire, about 5 mm. long; style less than half the length of t
corolla tube. Western Colorado to California. Ty
locality; "On the Cedar Mountains, south of Great Sa
Lake," Utah.

Specimens examined: Utah; L. F. Ward, Mass Valley; M.
Jones, No. 1698, Dog Valley, 1880, Terminus near Salt Lake, 18
Summit, Owen's Valley, 1897: California; Mrs. C. C. Bruce, No. 2
Warner Mts., 1898: Colorado; T. S. Brandegee, near Mt. Carbon,
Mts., 1881.

P. HOODII Rich. Frankl. Journ. Appx. t. 28 (1823).

Densely tufted and much branched from a somewh
woody root; sparsely lanate; leaves subulate, apicula
with broader clasping bases, 4-10 mm. long; calyx 5-7 m
long, the teeth like the leaves, the thickened central p
tion of the latter produced into strong ribs on the tu
below; corolla white, the tube equalling or somewhat
ceeding the calyx, the lobes obovate, entire or mucrona
about 5 mm. long. Flowering early in the spring, on
plains and foothills from Saskatchewan to Montana
Wyoming.

Dr. Gray noted (Syn. Fl. 2:132), this seems to pass *canescens.* It is apparent, however, that many forms, lly from Montana, have been referred to the latter nore properly belong to this species.

imens examined: Assiniboia; John Macoun, 1894: Montana; nderson, Great Falls, 1885; J. W. Blankinship, Custer, 1890; illiams, No. 831, Great Falls, 1892; Mrs. J. J. Kinnedy, Mis- .: Wyoming; C. C. Parry, No. 231, "Upper Valley of Green ?).

II GLABRATA n. var.

brous except for a few lanate hairs on the calyx and ase of the leaves; the latter granular-roughened and reener than in the species; calyx teeth short; corolla ghtly exceeding the calyx.

s variety takes the place of the species on the plains thills of Eastern Wyoming. On account of its green, leaves it has usually passed as *P. caespitosa.* It has r none of the pubescence characteristic of that species while what little it has is like that of *P.*

imens examined: Wyoming; Dr. F. V. Hayden, "Deer 0 miles above Ft. Laramie," 1860; E. L. Greene, Cheyenne, eled P. Douglasii); Geo. Engelmann, Sherman, 1880; B. C. Laramie, 1891; Aven Nelson, Laramie, 1892; J. Schneck, ction, 1893; Aven Nelson, Nos. 8 (1894, the type, in Herb. Wyo.), 1892 (1896) and 2864 (1897), Laramie: Montana; J. M. . Robinson, 1897: Colorado; North Park, 1897.

COLA (Britt.) n. sp.

P. Douglasii var. longifolia A.Gray, Proc. Am. Acad. 8:254 (1870). *P. Douglasii var. andicola* Britt. Mem. Torr. Club, 5:269 (1894).

ms from a rhizome, usually erect, often branched urface of the ground and with opposite branches at les, white, the bark exfoliating with age in thin 5-10 cm. high; sparsely lanate on the calyx and bases eaves, the stems granular-pubescent and somewhat glandular; leaves acerose or sublate or the larger plai often somewhat bisulcate, pungent, 1-2 cm. long; flowe sessile or on peduncles 2 mm. long; calyx teeth as long the tube, pungent; corolla white, the tube somewhat hai near the base within, one and a half times the length of th calyx, the lobes broadly obovate, 5-7 mm. long; style abo the length of the calyx. On the plains east of the Rock Mountains, from Montana to Western Nebraska a Eastern Wyoming. The range given by Dr. Gray at pla of original publication is, "east of the Rocky Mountains a in Utah."

In 1870 Dr. Gray described *P. Douglasii var longifoli* giving it the following characters: "Ramis saepius erect e rhizomate prostrato; foliis angustissime vel aceroso-li earibus lin. 5-8 longis minus fasciculatis." He gives i range as quoted above but it will be noticed that in t Synoptical Flora ("W. Nebraska to Oregon and N. E. Ca fornia") he also includes some far western forms. I ha seen no specimens from Oregon or California, which cou be associated with any of those forms from east of t Rocky Mountains, which might be supposed to belong this variety. Forms like Mr. Lemmon's No. 178 represe perhaps what Dr. Gray later (in 1878) included in *P. Dou lasii longifolia*. Since those far western forms do not diff in any marked respect from the true Douglasii and are far much nearer to it than to the forms east of the Roc Mountains it is best to leave them with that species.

It is probable that Dr. Gray included some forms of t recent *P. austromontana* and especially the variety *prostra* in his *P. Douglasii longifolia*, and indeed some Utah spe mens are so labeled. Even if we knew exactly what Ut specimens Dr. Gray referred to, the name *andicola* cou not properly be applied to them, for we have reason believe that he based his variety principally upon plan from "east of the Rocky Mountains." The forms found the last named region will therefore have to bear that nam Of these there are two which are quite distinct, name *iflora* and the one described above. Since one of as been definitely designated as *P. multiflora*, it is y proper to apply the name *andicola* to the remain-. We are also borne out in such disposition by the t the original characterization points to it rather *P. multiflora.* The latter has no true rhizomes, but e persisting stems instead, and its annual stems are one-flowered, while in *P. andicola* they bear several They differ also in the character of their pubes-e latter being lanate, while that which often occurs eduncles and calyx of *P. multiflora* can be termed nt (in the restricted sense). In habitat they differ *P. andicola* growing on the open plains, while *P.* *a* is only found in the hills.

ome respects the species in question is allied to *P.* It has the same character of pubescence and the ear striking resemblances. The habitat is the same ontana there occur some intermediate forms.

mens examined: Wyoming; B. A. Soulard, "On the Upper er," 1845; Aven Nelson, No. 397, Fairbanks on the Platte, raska; J. M. Bates, Valentine, 1895: North Dakota; Dr. F. n, "common on high praries from Fort Pierre to 'bad lands," ntana; R. S. Williams, No. 117, Belt River, 1881; also a by Hall and Harbour, No. 453, from Colorado, probably grees, 1862.

ves not beset with woolly cobwebby hairs.

ves ovate, oblong-linear or lance-linear, hispid-ciliate on the especially near the base, rarely naked.

ENSATA (A. Gray) n. sp.

P. Hoodii var. A Gray, Enum, Pl. Parry. (298) in Sill. Journ. *P. caespitosa var. condensata* A. Gray, Proc. Am. Acad. 8: 254 (1870).

sely pulvinate-tufted; leaves much imbricated, rigid, inear, apiculate, distinctly bisulcate, hispid-ciliate argins and slightly glandular, 5-6 mm. long; calyx as long as the leaves, the teeth oblong-linear, apiculate; corolla white, the tube twice the length of the calyx or less, somewhat hairy at the base within, the lobes rotund, 4-5 mm. long; style shorter than the calyx. At high altitudes in Colorado.

This should have specific rank. It is remarkably distinct from *P. caespitosa* which is less densely tufted and has larger leaves and flowers.

Specimens examined from Colorado: C. C. Parry, "From the headwaters of Clear Creek, and the alpine ridges lying east of Middle Park," 1861; Hall & Harbour, Lat. 39-41 degrees, 1862; Dr. Geo. Vasey on Powell's Colorado Exp. Exp., 1868; Hooker & Gray, No. 11.206, Sierra Blanca; F. S. Brandegee, No. 689, Sierra Sangre de Cristo Range, 1873 and 1874; H. N. Patterson, No. 101, Gray's Peak, alt. 11-14000 ft., 1885; Wm. Trelease, Leadville, 1886; Crandall & Cowen Mts. above Como, alt. 12,000 ft., 1895; C. S. Crandall, Mts. above Boreas, 1897.

P. CONDENSATA HENDERSONI n. var.

Very viscid, the surface of the leaves covered with fine glandular-tipped hairs, much more densely so than in the species.

Type in Herb. Agr'l. Coll., Wash.; collected by L. F Henderson, Mt. Adams, Washington, Aug. 10, 1892; als from the same locality by W. N. Suksdorf, 1884.

P. CAESPITOSA Nutt. Journ. Acad. Phila. 7:41 (1834).

Densely or somewhat loosely caespitose, often wit long, prostrate stems; leaves oblong-linear or lanceolat apiculate, 8-14 mm. long, 1-2 mm. wide, usually plane, th somewhat cartilaginous margins hispid-ciliate or naked, sur face glabrous or with short scattered glandular-tippe hairs; flowers sessile or subsessile (peduncles rarely 2 mm long); calyx more or less hispid-ciliate and usually wit some short glandular-tipped hairs, the teeth the length the tube, lanceolate or narrowly so, pungent; corolla whit or light blue, the tube slightly hairy at base within, abou three times the length of the calyx teeth, the lobes broadl obovate, 5-7 mm. long. In the mountains from New Mexic

ntana. Type locality; "Flat-Head river, on the sides
hills." •

**ecimens examined: New Mexico; N. K. Berg, Franklin, "tim-
e," 1897: Colorado; A. Eastwood, La Plata Mts., 1892; Baker,
and Tracy, No. 249, Mt. Hesperus, No. 635, Little Kate Basin,
a Mts., alt. 12,000 ft., 1898: Utah; M. E. Jones, No. 594c, Marys-
894: Wyoming; Aven Nelson. No. 1827 (1895), Elias Nelson,
6 (1898), La Plata Mines, alt. 12,000 ft.: Montana; J. B. Alle-
Wisconsin Creek, 1892; Emma J. Ware, Deer Lodge Co. (a
-leaved, very glandular form).**

ESPITOSA RIGIDA (Benth.) A. Gray. *P. rigida*
Benth. in DC. Prodr. 9:306 (1845). *P. caespitosa*
var. rigida A. Gray, Proc. Am. Acad. 8:254 (1870).

have seen no specimens of this variety. It was origin-
escribed from the Blue Mountains of Oregon (in mon-
caeruleis Americae boreali-occid.), and is perhaps con-
o the mountains of the Pacific coast states. Watson
s it from the Clover mountains of Nevada (Bot. King.
Since specimens are not at hand I retain this as a
. An examination of good material might prove it
more properly a species.

ILLEI n. sp.

epressed-caespitose; leaves ovate, oblong or linear-
, apiculate, 3-5 mm. long, hispid-ciliate on the
ned cartilaginous somewhat inflexed margin as also
pper surface, a little glandular and granular-
ened, central portion thickened and with a groove on
side; flowers sessile; calyx 5-7 mm. long, hispid-ciliate
andular, teeth thick, short or as long as the tube, the
l portion produced into thick cartilaginous ribs on
lyx tube below; corolla white, the tube quite hairy at
ithin, more than twice the length of the calyx, the
broadly obovate to rotund, 4 mm. long; style short,
an half the length of the corolla tube.

is cannot be referred to *P. caespitosa.* The much
r, broader leaves, and the grayish color of the whole

plant, distinguish it from that species. In leaf characters it seems to be allied to *P. albomarginata*. That species, however, has plane leaves and the flowers are raised above the ground and, at least in the variety *minor*, peduncled.

I take great pleasure in dedicating this species to Frederick Coville, who, together with Frederick Funston, collected it on the Death Valley Expedition. Type in Herb. California Academy of Sciences; No. 1801, Black Canon, White Mountains, Mono Co., California, 1891.

P. ALBOMARGINATA Jones, Zoe 4:367 (1894).

Specimens of this species are not at hand. It is characterized by its short, broad cartilaginous marginal leaves and exceedingly glandular calyx. Type locality; "East face of Mt. Helena, Montana."

P. ALBOMARGINATA MINOR Jones, l. c.

A specimen collected at Helena, Montana, by F. D. Kelsey, 1890, I take to be of this variety. It differs from the species in the absence of flowering stems, in its smaller leaves and shorter calyx. The flowers are on peduncles about 6 mm. long.

‡‡Leaves not hispid-ciliate on the margin.

||Sparsely lanate- or hirsute-ciliate on the calyx and usually at the base of the leaves, otherwise glabrous or with short fine glandular-tipped hairs on the leaves and stems; leaves acerose (at least those fascicled in the axils).

P. DIFFUSA Benth. Pl. Hartw. 325 (1849). *P. Douglasii var. diffusa* A. Gray, Proc. Am. Acad. 8:254 (1870).

Loosely caespitose-spreading, with prostrate loosely branched stems, the annual ones of 1-4 nodes, one-flowered, 2-3 cm. long; leaves 6-12 mm. long, a pair of spreading oblong-linear (2 mm. wide or less) ones with narrow thin white margin and somewhat narrowed base at each node, with acerose, apiculate ones in their axils; flowers sessile

ubsessile; calyx sparsely lanate-ciliate or sometimes
rous, the teeth the length of the tube; corolla white, the
somewhat hairy at base within, twice the length of the
x or less, the lobes obovate or broadly so, entire or
, 6-9 mm. long; style usually nearly equalling the
la tube. Oregon to British Columbia.

r. Gray made this a variety of *P. Douglasii* but that
not seem satisfactory, for it exhibits some very good
nctions from that. It is much laxer in growth, the in-
des being longer, and has broader and shorter leaves
onger style. It also grows in much moister places and
a more northern distribution.

pecimens examined: Washington; L. F. Henderson, Mt.
s, 1892, "Alpine slopes, Olympic Mts.," 1890; Lake & Hull, No.
orse-shoe basin, near Skagit Pass, 1892; C. V. Piper, Olympic
Mt. Rainier, 1895; O. D. Allen, No. 265, 1896: Oregon; Elihu
No. 414, 1871; L. F. Henderson, Summit of Ashland Butte, 1886:
h Columbia; John Macoun, Mt. Arrowsmith on Vancouver Is-
1887.

UGLASII Hook. Fl. Bor. Amer. 2:73 (1838).

aespitose, often loosely so with much-branched pros-
stems from a more or less woody root; sparsely lanate-
e on the calyx, base of leaves and stems or nearly
ous; leaves acerose, pungent or apiculate, 5-15 mm.
flowers sessile or subsessile, solitary, rarely the an-
stems 3-flowered; calyx teeth the length of the tube,
se-subulate; corolla white or light blue, the tube some-
hairy at base within, a little less than twice the length
calyx, the lobes obovate to rotund, 5-7 mm. long; style
he length of the corolla tube or less. Common in Ore-
nd California, also in Idaho, Nevada, and southwestern
ado. Type locality; "N. W. America: common on the
stone range of the Blue Mountains (Oregon), and on
ocky Mountains, near the confines of snow."

f all the forms, merged into this species by Dr. Gray,
ne so common in Oregon and California is here taken
e true *P. Douglasii.* The leaves of this are not notice-
rigid but often rather weak and spreading. They are

either strictly acerose or somewhat plane and often with inflexed but not at all thickened margins. As a rule they are not grooved, at least not so strongly or distinctly as in *P. condensata*. In the specimens examined there is some variation especially in habit but not marked enough to justify any further seggregation. The Oregon specimens have a much softer pubescence and approach much nearer to *P. diffusa* than some of those from California. The latter, of which Coville and Funston's No. 1830 and Lemmon's 178 are representatives, exhibit a coarser, somewhat hirsute pubescence and the annual stems are often 3-flowered.

Specimens examined: Washington; Mrs. W. L. Steinweg, Cascade Mts., Yakima Co., 1894: Oregon; Dr. J. H. Bartholf, Camp Harney, 1875; Mrs. R. M. Austin, Southeastern Oregon (labeled P. Douglasii longifolia), Quartz Valley (labeled P. caespitosa), 1893; C. V. Piper, Powder River Mts., 1896; L. F. Henderson, Mt. Hood, 1896 (labeled P. Douglasii diffusa): Idaho; A. Isabel Mulford, near Ketchum, 1892: California; J. G. Lemmon, Nos. 81, Sierra Valley, and 178, Sierra Co. 1874 (labeled P. Douglasii longifolia); Geo. Engelmann, Mt. Shasta, 1880; M. E. Jones, No. 2470, Soda Springs, Nevada Co. 1881; Mrs. Austin, Davis Creek, 1892; Geo. Hansen, No. 499, Amador Co., 1892 and 1895 (labeled P. caespitosa); C. A. P——, Tulore Co., 1896; Mrs. C. L. Proctor, Mt. Shasta, 1896; H. E. Brown, No. 362 1-2, Mt. Shasta, 1897 (labeled P. caespiosa); Alice Eastwood, Summit, Placer Co., 1898: Nevada; M. E. Jones, Carson City, 1897: Southwestern Colorado; Alice Eastwood, Mancos, 1891.

P. PIPERI n. sp.

Many-stemmed and much branched from a woody root, the woody persistent stems erect or ascending, 10-15 cm. high, these often arising from horizontal rhizomes; the whole plant sparsely covered with short, fine, glandular tipped hairs throughout, the bases of the leaves and the calyx hirsute-ciliate; leaves spreading, acerose, pungent 5-10 mm. long; flowers solitary, usually on peduncles 2 mm long; calyx teeth acerose, pungent; corolla white or light blue, the tube somewhat hairy at base within, one and a half times to twice the length of the calyx, the lobes obovate to cuneate-obovate, 6-9 mm. long; style about half the length of the corolla tube.

ype in Herb. Agr'l. Coll., Wash; collected by C. V.
at Spokane, Washington, May 16, 1896; from the same
y by A. A. and E. Gertrude Heller, April 21, 1896. A
nen by W. C. Cusick, No. 1601, from Easetrn Oregon
is also referred here.

Pubescent or canescent-pubescent, never glandular, often en-
glabrous; leaves plane or subulate from a broader base.

STROMONTANA Coville, Cont. Nat. Herb. 4:151
(1893).

outhern Utah, northern Arizona and southern Cali-
Type locality, "Beaverdam Mountains, Utah."

his excellent species is characterized by its canescent
ence and by the replicate sinuses of the calyx. It is
relative of *P. Douglasii* which it resembles in habit,
ffers from that in the above named characters and in
eral flowered annual stems. The leaves are acerose
a broader base and usually somewhat bisulcate or
nearly plane. The corolla tube is rather noticeably
near its base within.

cimens examined: Southern Utah; C. C. Parry, Mts. near St.
1874; A. H. Siler, No. 16, Mts. near Osmer, 1874; Dr. E.
No. 307, "S. Utah, N. Arizona," 1877; M. E. Jones, No. 5122,
d Valley, 1894: California; C. R. Orcutt, No. 885, Topo Canon,
B. Parish, Nos. 1839 (1886) and 2955 (1894) San Bernardino

TROMONTANA PROSTRATA n. var.

osely caespitose-spreading, with long prostrate laxly-
ed stems which are often 3 dm. long; leaves usually
20-25 mm. long; flowers large, the corolla tube 2 cm.
he lobes erose, 1 cm. long.

has the canescent pubescence and the replicate calyx
of the species, but its more diffuse habit and its
planer leaves readily distinguish it.

pe in Herb. Univ. of Wyo.; collected by M. E. Jones,
3 y & z, at Silver Reef, Utah, May 4, 1894.

P. MULTIFLORA Aven Nelson, Bull. Torr. Bot. Club, 25:278 (1898). *P. Douglasii var. longifolia.* A. Gray, Proc. Am. Acad. 8:254 (1870), in part.

In the foothills east of the Rocky Mountains, from Montana to Colorado. Type locality; Laramie Hills, Albany Co., Wyoming.

This species is very distinct and need not be confused with anything else. Its simple, erect, one-flowered annual stems with comparatively long internodes and little if at all fasicled plane leaves separate it from all related species. The plant is often glabrous throughout, but generally the calyx and peduncles are pubescent. The same hairiness in the corolla tube observed elsewhere in this group also occurs here.

Specimens examined: Montana; J. H. Flodman, Spanish Basin 1896; P. Koch, Lake Plateau, 1897: Wyoming; Dr. F. V. Hayden "Summit of Wind River Mts.," 1860; C. C. Parry, "N. W. Wyo.," 1873; J. W. Blankinship, Big Horn Mts., 1890; B. C. Buffum, Upper Laramie River, 1891; Aven Nelson, Nos. 182, 1894, and 3175 (type) 1897, Laramie Hills, No. 813, Union Pass Hills, 1894; Elias Nelson No. 4864, Freezeout Hills, 1898: Colorado; W. A. Henry, Gregory Canon, 1875; J. J. McFarland, Boulder Co., 1881; Alice Eastwood Durango, 1891; C. S. Crandall, Mountans of Northern Colo., 1890 Rist Canon, 1891, Platte Canon, 1894; C. F. Baker, Ft. Collins, 1896

P. MULTIFLORA DEPRESSA n. var.

Depressed caespitose, scarcely rising above the ground leaves 1 cm. long, rarely 2 cm.; flowers mostly subsessile the corolla lobes 6-7 mm. long (in the species 8-9 mm).

I thus designate a form from the Red Desert of South Western Wyoming. Type in Herb. Univ. of Wyo.

Specimens examined from Wyoming: Dr. F. V. Hayden, Kama Prairie and head of Wind River Valley, alt. 6500, 1860; Aven Nelson Nos. 3084 (type), Point of Rocks (1897), 4677, Kemmerer, and 453 Cokeville (1898).

‖ ‖ ‖Pubescent or hirsute, often glandular, not infrequently e tirely glabrous; leaves plane, lance-linear.

ELSEYI Britt. Bull. Torr. Bot. Club, 19:225 (1892).
'rom Montana and the Dakotas to Southern Wyoming.

'his varies from entirely glabrous to densely hirsute,
ome specimens from southern Wyoming are glandular
ghout; but, since this form agrees in every other re-
and since some Montana plants also exhibit a ten-
to be glandular, it seems best to refer it to this
es. The peduncles and young stems are narrowly wing-
d, a character which is never so prominent in any other
es. The membranous sinuses of the calyx are very
w, and show no indications of becoming replicate.

ecimens examined: Montana; F. D. Kelsey, Helena, 1890,
d'Alene, 1891; Mrs. L. A. Fitch, Twin Bridges, 1892, Madison
H. Flodman, Little Belt Mts., 1896: South Dakota; Alice D.
Piedmont, 1895; J. M. Bates, No. 1152, Hot Springs, 1896:
ing; J. M. Bates, Newcastle, 1896; Elias Nelson, No. 4336,
Creek, Albany Co., 1898 (the glandular form).

ADIFORMIS (Jones) n. sp.

P. longifolia var. gladiformis Jones. Proc. Cal. Acad.
Sci. Ser. 2, 5:711 (1895).

oosely caespitose with prostrate spreading stems;
pubescent and slightly glandular throughout; leaves
thick and rigid, with prominent midribs and slightly
te margins, lance-linear, pungent, 15-20 mm. long,
2 mm. wide; flowers sessile or subsessile; calyx with
s distinctly but only moderately replicate, the teeth
ly longer than the tube, pungent; corolla white, the
pubescent (on the exterior) and near the base within
densely so, twice the length of the calyx, the lobes
e-obovate, entire, 7 mm. long; style less than half the
of the corolla tube. Utah. Type locality; "Cedar
Utah.

he nearest relative of this is *P. Kelseyi* with which it
in habit and leaves. It is readily distinguished from
y its more sessile flowers, pubescent corolla tube and
character of its calyx. Mr. Jones referred it to *P.
lia*. The replication of the calyx sinuses would in-

deed suggest such relationship, yet it has neither the long style nor the habit which is characteristic of that group. On the other hand its chief characters allies it to *P. Kelseyi* and were it not a good species it would have to become a variety of the same. The above description has been drawn from some specimens of Mr. Jones' type number, 5208c, collected by him at Cedar City, Utah, May 8, 1894.

**Suffrutescent or nearly herbaceous perennials, loosely tufted and many-stemmed; leaves generally distant, very little if at al fascicled in the axils, as a rule not marcescent on the stems below; flowers in corymbose cymes; calyx with white-membranous intercostal sinuses which are usually replicate and often produced into salient angles, the teeth equalling or shorter than the tube, apiculate or pungent; corolla tube more or less hairy at base within; style long and slender equalling the corolla tube or at least longer than the ovary or stigmas; ovules one or two in each cell.

†Corolla tube glabrous.

‡Style exceeding the calyx.

||Corolla tube twice the length of the calyx or less.

a. Flowers nodding.

P. CERNUA n. sp.

Suffrutescent at base and many-stemmed, 8 cm. high the lower part of the stems purple; glabrous throughout o the stems puberulent below; leaves linear, spreading, 2- cm. long, less than 2 mm. wide; flowers on slender pedicel (about 1 cm. long), inclined to be nodding; calyx with somewhat replicate sinuses, the teeth half the length of the tube corolla white or tinged with purple, the tube twice th length of the calyx, the lobes obovate, entire or somewha erose, 7-8 mm. long; ovules solitary in each cell.

Type in Herb. Univ. of Wyo.; collected by C. S. Crandall at Cimarron, Montrose Co., Colo., May 18,1898.

aa. Flowers not nodding.

P. LINEARIFOLIA (Hook.) A. Gray. *P. speciosa* Lind Bot. Reg. t. 1351 (1828). *P. speciosa var. linearifol*

Hook. Kew. Journ. Bot. 3:289 (1851). P. linearifolia A. Gray, Syn. Fl. 2:133 (1878).

Loosely tufted, more or less suffrutescent with erect or
urgent stems; entirely glabrous or roughish pubescent;
'es narrowly linear, pungent, 2-5 cm. long, 1-2 mm. wide;
'ers as a rule long-pedicelled; calyx more or less angled
he replication of the sinuses, often strongly so, the teeth
newhat acerose, pungent, about the length of the tube,
olla white, blue or rose-color, the tube less than twice
length of the calyx, the lobes obovate or narrowly so,
ally entire, 8-12 mm. long; ovules 1or 2 in each cell. On
interior plains of the Columbia River and its tributaries
Vestern Idaho, Washington and Northern Oregon. Type
lity; "N. W. America, Plains of the Columbia."

This species presents considerable variation in habit
degree of pubescence. Forms like C. V. Piper's speci-
s from Almota, Washington, have usually passed as
nearifolia among recent collectors, while glabrous forms
e been labeled *P. longifolia.* It is not readily distin-
hed from *P. longifolia.* which displaces it in the Rocky
ntain region but is however as a rule separated from
by its shorter and narrower leaves.

Specimens examined: Idaho; J. H. Sandberg, No. 25, "Common
illsides, valley of Clearwater River, Nez Perces County," 1892.
s form is erect in habit, many-stemmed from the base and
rous or only slightly pubescent, with calyx moderately angled
two ovules in each cell. It seems to fit the description of P.
osa Lindl. in Hook. Fl. Bor. Am. 2:72 as well as any specimens
); L. F. Henderson, Lewiston, 1894; A. A. & E. Gertrude Heller,
ston, 1896 (glabrous, leaves even 5 cm. long; calyx 15 mm. long,
es 2 in each cell): Washington; Chas. A. Ramm,
ane, Co., 1883 (slender form); L. F. Henderson,
gue, 1892, Yakima, 1892 (corolla lobes obovate, 7 mm.
); W. R. Hull, Pataha, 1892; E. R. Lake, Wawawai, 1892; C. V.
, Almota, 1893 (very pubescent, persisting stems prostrate, the
al ones erect or assurgent, corolla lobes narrowly obovate, 10-12
long, ovules usually 2 in each cell); C. V. Piper, Wawawai, 1893
escent, corolla lobes 15 mm. long, acuminate-acute); Mrs. W. L.
weg, North Yakima, 1894; H. H. Hindshaw, Pasco, 1896; C. V.

Piper, North Yakima, 1898 (a low form with weak stems and green spreading leaves, about 2 cm. long, glabrous, calyx strongly angled, corolla lobes mostly cuneate-oblong, 6-9 mm. long, ovules 2 in each cell): Oregon; Rev. M. Spalding, Clearwater, No. 11,963.

P. VIRIDA n. sp.

Rather woody at base, the annual stems numerous erect and leafy, 6-10 cm high, rarely 15 cm; glabrous below, viscid-pubescent above and with a few longer crisp hairs on the calyx; leaves noticeably green, linear, pungent, 2-3 cm. long, 1 mm. wide; flowers usually in contracted corymbose cymes, with rather stout pedicels; calyx moderately angled by the replication of the sinuses, the teeth the length of the tube and pungent; corolla light blue, the tube somewhat exceeding the calyx, the lobes cuneate-obovate, emarginate or nearly obcordate, 6-7 mm. long; ovules solitary in each cell.

Characterized by its viscid pubescence and unusually green leaves. Type in Herb. Agr'l. Coll. Wash.; collected by C. V. Piper, Ellenburg, Washington, May 20, 1897; also, from Idaho, by A. Isabel Mulford, Boise flats, 1892.

P. VISCIDA n. sp.

Stems erect, 10-15 cm. high; viscid pubescent throughout, the pedicels and calyx densely so, the latter also somewhat hirsute; leaves noticeably green, linear to narrowly lanceolate, pungent, 2-4 cm. long, 2-4 mm. wide; flowers on pedicels 1-2 cm. long; calyx 13 mm. long, with sinuses only slightly replicate (in type apparently not at all), the teeth about the length of the tube, green, apiculate; corolla rose-color (?), the tube slightly exceeding the calyx, the lobes obovate or narrower, finely erose, 7 mm. long; ovules solitary in each cell.

I confidently propose this as a new species. Its viscid pubescence and much broader leaves at once distinguish it from *P. longifolia* and *P. linearifolia.* It has been labeled *P. longifolia var Stansburyi,* with which it cannot be associated, its relationship being rather with *P. longifolia.* Type in Herb. Agr'l. Coll., Wash.

ecimens examined: Washington; Thos. Howell, No. 1380,
at Valley, 1881; C. V. Piper, Blue Mts. Columbia Co., June 15,
ype): California; H. N. Bolander.

NGIFOLIA Nutt. Journ. Acad. Phila. 7:41 (1834).
. *P. speciosa var. b* Hook. Fl. Bor. Am. 2:72 (1838).
P. humilis Dougl. Benth. in DC. Prodr. 9:306 (1845).

sually erect in habit, 10-25 cm. high; finely pubescent
brous; leaves linear, with prominent midveins and
hat thickened cartilaginous margins, 3-6 cm. long,
n. wide; flowers on pedicels 1-3 cm. long; calyx with
y replicate sinuses; corolla white, the tube somewhat
ing the calyx, the lobes obovate or cuneate-obovate,
emarginate or erose, 8-10 mm. long; ovules generally
y in each cell. Along the western side of the Rocky
ains from Montana to Colorado and Utah, also in
(Blue Mountains) and Washington.

ooker gives as the range of his *P. speciosa var b*,
pine range of the Rocky Mountains near perpetual
and on the Blue Mountains, N. W. Am.," which indeed
to be nearly the range of this species for although it
s principally to the Rocky Mountain region a low far
n form must also be referred here. *P. humilis*, a
growing "in aridis sabulosis ad. flum. Columbia
ae boreali-occid.," is *P. speciosa var b*, Hook. in part.
robable that Douglas based his *P. humilis* on speci-
imilar to those cited below from Oregon and Wash-
There seems to be nothing however which would
t its separation from *P. longifolia*.

the whole it is a little stouter in habit and with
pedicels than *P. linearifolia*. Its pubescence is finer
e ovules are seemingly always solitary in each cell.
south it gradually passes into *P. Stansburyi*, yet from
ical forms of that it is readily distinguished.

imens examined: Montana; F. V. Hayden, Madison River,
. F. Shaw, Bozeman, 1892; Mrs. C. H. Moore, Butte, 1893;
dgman, Gallatin Co.: Wyoming; F. V. Hayden, (a series of

collections), Jackson's Hole, 1860; Aven Nelson, No. 4629, Cokeville, 1898: Colorado; J. H. Cowan, Leroux Creek, Delta Co., 1892; C. S. Crandall, Palisades, Mesa Co., 1898: Utah; M. E. Jones, Salt Lake City, 1880: Washington; Kirk Whited, Weuatchee, 1896: Oregon; Rev. M. Spalding.

P. LONGIFOLIA PUBERULA n. var.

Low, 1 dm. high or less, stems erect or ascending; more or less glandular-puberulent, very densely so on the pedicels and calyx, nearly destitute of roughish hairs; leaves usually spreading, linear, bluntish at tip or apiculate, 2-4 cm. long, 1-2.5 mm. wide; replication of the calyx sinuses very slight and inconspicuous; corolla light blue or lilac, the lobes obovate or cunate-obovate, retuse or blunt, 7-12, mm. long; ovules solitary in each cell.

I thus designate what seems to be quite a distinct form which, were it not for its gradual gradation into *P. longifolia*, would be a good species. Type, No. 4544, in Herb Univ. of Wyo.; collected by Aven Nelson at Evanston, Wyo. June 5, 1898; also No. 2964, from same locality, 1897.

P. STANSBURYI (Torr.) Heller, Bull. Torr. Bot. Club 24:478 (1897). *P. speciosa var.* (?) *Stansburyi* Torr Bot. Mex. Bound. 145 (1859). *P. longifolia var* *Stansburyi* A. Gray. Proc. Am. Acad. 8:255 (1870

Stems several from a ligneous base, rather stout usually simple below, cymosely branched above into leafy bracted corymbs, about 1 dm. high; pubescent throughout roughly so above, the pedicels and calyx usually glandular leaves thick, usually recurved-spreading, linear or linear lanceolate, apiculate, 20-35 mm. long, 2-3 mm. wide; flower on pedicels 5-15 mm. long; calyx 1 cm. long, the sinuse more or less replicate, the teeth apiculate or somewhat cuspidate attenuate, as long as the tube; corolla pink or rose color, the tube fully twice the length of the calyx, the lobe cuneate-obovate, erose, emarginate or retuse, 7-8 mm. long ovules usually one in each cell. Southern California to Nev Mexico, Southern Colorado and Utah. Type locality; Orga and San Luis Mountains, New Mexico.

Specimens examined: California; Coville and Funston, No. 744,
mint Mts., 1891: Utah; Henry Englemann, Salt Lake City, 1872;
. Jones, Cisco, 1890, No. 5198, Cedar City, 1894; Arizona; E. Pal-
Cottonwood Creek, 1876; H. H. Rusby, 1883; M. E. Jones, 1884;
Pringle, Santa Rita Mts., 1884; C. G. Pringle, Santa Rita Mts.,
New Mexico; E. O. Wooton, No. 158, Organ Mts., 1892; A. A
E. Gertrude Heller, Barranca, 1897: Colorado; T. S. Brandegee,
's Canon, 1878; Alice Eastwood, Crested Butte, 1890.

ANSBURYI BREVIFOLIA (A. Gray) n. com.

P. longifolia var. Stansburyi A. Gray forma brevifolia A. Gray, Proc. Am. Acad. 8:255 (1870). *P. longifolia var. Stansburyi A. Gray subvar. brevifolia* A. Gray, Wats. in Bot. King Surv. 261 (1871). *P. longifolia var. brevifolia* A. Gray, Syn. Fl. 2:133 (1878).

Low, 5-6 cm. high; leaves short and broad, ovate to
eolate or narrowly oblong, apiculate-acute, 6-15 mm.
3-4 mm. wide; pubescent throughout, the pedicels and
glandular.

pecimens examined: Nevada; M. E. Jones, Reno, 1897: Northern
na; E. Palmer, No. 306, 1877.

||Corolla tube tubular-funnelform, nearly twice the length of
lyx.

ENUIFOLIA n. sp.

Erect suffruticose perennial, 5 dm. high or more, the
al stems 25-30 cm. long, the internodes often 6 cm. long;
rous below, sparsely glandular-pubescent above, the
hirsute-ciliate; leaves linear-attenuate, 25-35 mm.
; flowers in lax irregular corymbose cymes, the pedicels
long; calyx 6-10 mm. long, with sinuses barely if at all
cate, the teeth lanceolate-attenuate, shorter or even
er than the tube; corolla white, the tube twice as
d at throat as at base, nearly twice the length of the
, the lobes oblong or cuneate-oblong, erose, 8 mm.
; ovules solitary in each cell.

The type of this excellent species is in Herb. Mo. Bot.

Garden; colected by C. G. Pringle in the "Rocky canyons of the Santa Catilina Mts.," Arizona, April 11, 1881. It has also been collected by J. W. Toumey in the same locality and by W. T. Parish at Lowell, Ariz.

|| || ||Corolla tube 3 to 4 times the length of the calyx.

P. DOLICANTHA A. Gray, Proc. Am. Acad. 22:310 (1887)

Herbaceous to the ground, about 1 dm. high, the stems branched, the branches opposite below and equalling the main stem; sparsely pubescent more or less throughout with short glandular-tipped hairs, noticeably so on the pedicels and calyx; leaves thick and with prominent midribs, alternate above, linear to lanceolate, the larger ones with occasional retrose teeth, those on the main stems 30-50 mm. long, 5-8 mm. wide, those on the branches 25-35 mm. long, 2-4 mm wide; flowers scattered, on stout pedicels, the latter 10-25 mm. long; calyx with sinuses barely if at all replicate, the teeth slightly shorter than the tube; corolla rose-color (?) the tube 3-4 times the length of the calyx, the lobes obovate entire, 9-10 mm. long; ovules solitary in each cell. San Bernardino Mountains of southeastern California and Pahranagat Mountains of southeastern Nevada.

Specimens examined from southeastern California: S. B. Parish Nos. 1880, 1838 (1886) and 2956 (1894), San Bernardino Mts.

‡‡Style not exceeding the calyx.

P. HIRSUTA n. sp.

Very woody at base with stout annual stems, the latte about 1 dm. high; coarsely hirsute throughout with lon jointed hairs; leaves thick and rigid with granular roughened and often a little revolute margins, ovate to lanceolate, on sterile shoots linear, about 2 cm. long; flower subsessile or short-pediceled; calyx with very narrow white membranous sinuses not replicate, the teeth rigid and somewhat bisulcate, lanceolate or linear, apiculate; corolla tub exceeding the calyx; corolla lobes broadly cuneate-obovate entire, about 8 mm. long; style 4 mm. long, shorter than th calyx; ovules solitary in each cell.

The short style and hirsute pubescence distinguish this
any of the other species of this group. Its relationship
pparently with *P. Stansburyi var brevifolia.* The type is
e Herb. Mo. Bot. Garden; collected by E. L. Greene, No.
near Yreka, Siskiyou County, California, May 26, 1876.

†Corolla tube slightly pubescent.

DSURGENS Torr. Gray, Proc. Am. Acad. 8:256 (1870),
Gray, Syn. Fl. 2:133.

Oregon and Northern California. Type locality; "Canon
, Oregon."

pecimens examined: Oregon; Wm. C. Cusick, Linn Co.; Th.
ell, Coast Mts. near Roseburg, 1887; L. F. Henderson, Crow-
Mts., Glendale, 1887; Miss Chandler, Glenbrook, 1896: Cali-
a; Mrs. Stringer, Seiad Valley, Siskiyou Co., 1897.

**Suffrutescent or nearly herbaceous perennials, with more or
distant linear or lanceolate leaves; flowers in cymose clusters
attered; calyx with white membranous sinuses not replicate or
slightly so, rarely produced into salient angles; corolla tube
what hairy near the base within; slightly exceeding the calyx,
twice its length; style very short, not longer than the ovary
igmas; ovules 1 to 3 in each cell.

Ovules solitary in each cell; corolla lobes usually obcordate or
e.

NCEOLATA n. sp.

Stems short and stout, from a woody base, 10-15 cm.
; finely glandular-pubescent throughout, pedicels and
viscid; leaves thick and rigid, with prominent mid-
and cartilaginous margins, lanceolate, the upper dilated
ase, those on sterile shoots linear, 2-4 cm. long; flowers
ongested, leafy-bracted corymbose clusters; corolla
e, the tube slightly exceeding the calyx, the lobes
rdate or only retuse, about 8 mm. long; ovules solitary
ch cell. Washington.

A good species, characterized by its broad, thick, rigid
es, its viscid pubescence and very close flower clusters.

Type in Herb. Agr'l. Coll. Wash., collected by C. V. Piper Ellenburg, Wash. 1897; also, by L. F. Henderson, Clement's Mt., Yakima Co., Wash., 1897.

P. SPECIOSA Pursh, Fl. Am. Sept. 1:149 (1814).

Shrubby at base, erect in habit, 5-10 dm. high, profusely flowered; glandular-puberulent or viscid above, usually glabrous below; leaves with more or less prominent cartilaginous margins and the leaf surface nitidous under a lens linear, 4-7 cm. long, those on the sterile shoots about 2 mm wide, those on the flowering stems broader and the upper linear-attenuate from a dilated base; flowers in lax corymbose clusters; corolla rose-color or white, the tube a little exceeding the calyx, the lobes obcordate, 8-14 mm. long; ovules solitary in each cell. Western Idaho and Washington. Type locality; "On the plains of the Columbia."

Specimens examined: Idaho; L. F. Henderson, Juliaetta, Latah Co., 1895; A. A. & E. Gertrude Heller, Nez Perces Co., 1896: Washington; C. V. Piper, Almota, 1893, Pullman, 1893 and 1894; Sandberg and Leiberg, Spokane, 1893; A. D. E. Elmer, Nos. 148 and 839 Pullman 1896 and 1897.

P. SPECIOSA SABINI (Dougl.) A. Gray. *P. speciosa Lindl var. g* Hook. Fl. Bor. Amer. 2:72 (1838). *P. sabini* Dougl. in Hook. Kew. Journ. Bot. 3:289 (1851). P speciosa Pursh. var. Sabini A. Gray, Syn. Fl. 2:134 (1878).

Like the species but corolla lobes entire or nearly so Range of the species.

Specimens examined: Washington; W. R. Hull, Pullman, 1892 C. V. Piper, Almota, 1893: Idaho; L. F. Henderson, "Sunny Bluff near Juliaetta," 1895.

P. OCCIDENTALIS Durand, in Pacif. R. Rep. 4:125 (1856) *P. speciosa var. latifolia* Hook. Kew. Journ. Bot 3:289 (1851). *P. divaricata* Durand, Pl. Pratt. in Journ. Acad. Phila. ser. 2, 3 (1855).

More or less shrubby at base, 1-3 dm. high, stem

ly assurgent, often erect; glandular-puberulent or
what viscid above, often entirely glabrous; leaves lan-
te to linear, 3-5 cm. long, 4-9 mm. wide, those on sterile
s linear, about 4 mm. wide, flowers in leafy-
ed clusters; corolla white or rose-color, the tube some-
exceeding the calyx, the lobes obcordate, often deeply
12 mm. long; ovules solitary in each cell. California to
ington. Type locality; "Hill-sides, near Duffield's
h," California.

'his is intermediate between *P. Woodhousei* and *P.*
sa, differing from the latter in its broader leaves and
bracted flower clusters. It is very common in Cali-
, and extends northwards to Washington, while *P.*
sa seems to be confined to the region drained by the
bia River.

**ecimens examined: California; W. I. Fisher, No. 585, San
1876; E. L. Greene, No. 767, Yreka, Siskiyou Co., 1876; G. Eisen,
5, Fresco Co., 1877; Mrs. R. M. Austin, Plumas Co., 1877; J. G.
on, No. 37, Mts., Plumas Co., 1879; T. S. Brandegee, Amador
86; Geo. Hanson, Nos. 120 and 910 Amador Co., 1891, 1893 and
lice Eastwood, Sequoia Mills, Fresco Co., 1894; H. E. Brown,
5, Sisson, Siskiyou Co., 1897; M. E. Jones, Diamond Mt., 1897;
Rixford, Eldorado, 1898: Washington; T. S. Brandegee, No.
Yakima region of Cascade Mts., 1882; W. N. Suksdorf, No. 883,
No. 2208, Klickitat Co., 1893; Mrs. W. L. Steinweg, Cascade
394; Kirk Whited, Weuatchee, 1896.**

ODHOUSEI (A. Gray) n. sp.

P. nana Torr. in Sitgreaves Rep. 145 (1853), not
Nutt. *P. speciosa var. Woodhousei* A. Gray, Proc.
Am. Acad. 8:256 (1870).

ow, 5-10 cm. high, stems few from a ligneous base, the
sterile ones very leafy, the flowering ones corymbosely
ned above; glandular pubescent, usually glabrous
; leaves thick and rigid, those of the sterile shoots
g-linear, abruptly acute, 3-4 cm. long, 3-5 mm. broad,
of the flowering stems shorter and often nearly oblong,
all dilated at base; flowers few, on pedicels 5-20 mm.
calyx about 7 mm. long; corolla pink (?), the tube

usually twice the length of the calyx, the lobes cunea obcordate, usually deeply so, 6-8 mm. long; ovules solita in each cell. Arizona. Type locality; "lat. 35°, long. 11 20′."

A good species, having a distribution far removed fr the species to which it has been allied. Its small size a oblong-linear leaves distinguish it. It is very leafy at ba while the flowering stems are as a rule comparatively nak

Specimens examined from Arizona: E. Coues and E. Palm Nos. 122, 210, 308 and 376, Fort Whipple, 1865; Anderson, Willia Mt., 1865; H. H. Rusby, Ash Fork, San Francisco Mts., 1883; M. Jones, San Francisco Mts., 1890.

††Ovules 2 to 3 in each cell; corolla lobes entire or nearly s

P. TRIOVULATA Thurb. in Bot. Mex. Bound. 145 (185
P. nana var. glabella A. Gray, Proc. Am. Acad. 8:2
(1870).

Stems usually slender, simple or very little branch 1-2 dm. high somewhat canescent-pubescent throughout sometimes nearly glabrous; leaves nearly all opposi linear, 3-4 cm. long, 1-2 mm. wide; flowers few and oft solitary; calyx with sinuses very slightly replicate, ea plica often produced into a tiny spur near the base of t calyx; corolla "white" or "purplish," the tube usually g brous, somewhat exceeding the calyx, the lobes broa obovate entire or erose-denticulate, about 12 mm. lo ovules 2 or 3 in each cell. New Mexico and Southeast Arizona. Localities cited at place of original publicati "Ravines, Mule Spring," "Rio Mimbres" and "Escondid New Mexico.

This is sufficiently dintinct from *P. nana* to be a spec Its slender habit and narrow leaves at once separate it fr that. The corolla tube is also much more glabrous and calyx sinuses are inclined to be a little replicate. It var from somewhat canescent-pubescent to nearly glabro Originally it was described as "canescently pubescent." there are very few specimens to which that term can be

ied. For that reason Dr. Gray placed *P. triovulata* as
nonymn of *P. nana*, and named the slender glabrate form
nana var. glabella. Such disposition is not satisfactory,
r *P. triovulata* and *P. nana glabella* together constitute a
stinct species, having the same slender stems and narrow
aves and differing only in the amount of pubescence. The
ro numbers,504 and 1654,which Dr.Gray cites as belonging
the smoothish variety, are also cited at the original place
publication of *P. triovulata*, and a specimen seen of the
tter number is canescent-pubescent and has the tiny spurs
entioned in the description above.

Specimens examined: New Mexico; C. C. Wright, Nos. 504 (1849)
d 1864 (1851-52); A. Wislizenus, 1846-1847; E. O. Wooton, Nos. 13
d 447, Organ Mountains, Dona Ana Co., No. 575, White Mountains,
ncoln Co., 1897: Arizona; J. G. Lemmon, No. 415, Rucher Valley,
irricahua Mts., 1881.

NANA Nutt. Pl. Gamb. 153 (1848).

Herbaceous to the ground or somewhat ligneous at
ase, 1-2 dm. high, stems freely branched; roughish pubes-
nt throughout and more or less glandular; leaves spread-
g, opposite below alternate above, lance-linear, on the
ain stems 20-35 mm. long, 3-4 mm. wide, on the lateral
anches shorter and narrower; flowers scattered or some-
hat corymbose, on pedicels 5-35 mm. long; calyx teeth
ightly longer than the tube, green and apiculate; corolla
ed" or "white," the tube pubescent, somewhat exceeding
e calyx, the lobes broadly cuneate-obovate, entire or with
avy margins, often mucronate, about 15 mm. long; ovules
or 3 in each cell. Common in New Mexico, also in
rizona.

Specimens examined: New Mexico; A. Wislizenus, Las Vegas,
46; A. Fendler, Santa Fe Creek Valley, 1847; T. S. Brandegee,
nta Fe Co., 1879; George Englemann, "Hills and mountain sides
out Santa Fe and sandy soil along Santa Fe Creek," 1881; A. A.
E. Gertrude Heller, "Canon near Santa Fe," 1897: Arizona; J.
. Blankinship, Flagstaff, 1893.

****Annuals; calyx teeth spreading, linear or subulate-lanceolate.

setaceous-tipped, with age becoming recurved and split to the base or nearly so; corolla tube hairy near the base within; style not longer than the stigmas; ovules 1-5 in each cell. All Texan.

†Corolla tube pubescent, exceeding the calyx; ovules solitary in each cell.

P. ASPERA n. sp.

Annual (?) branched from the base, 12-17 cm. high, the stems simple and strict with opposite leaves up to the close cymose clusters of short-pedicelled flowers; pubescent throughout with short rigid hairs, the stems puberulent and with some longer spreading hairs, the pedicels and calyx glandular; leaves narrowly lanceolate to linear, 20-45 mm. long, 3-5 mm. wide, somewhat rigid and of firm texture; calyx teeth more or less purple, about twice the length of the tube, setaceous-tipped; corolla violet (?), the tube glandular-pubescent, nearly twice the length of the calyx, the lobes cunate-obovate, mucronate-acute, 12 mm. long; ovules solitary in each cell. Texas.

A well marked species, readily distinguished from *P. Drummondii* by its habit and entirely different character of pubescence. Type in Herb. Mo. Bot. Garden; collected by A. A. Heller at Kerrville, Kerr County, southern Texas, April 19-25, 1894.

P. DRUMMONDII Hook. Bot. Mag. t. 3441. Gray, Proc. Am. Acad. 8:257. Gray, Syn. Fl. 2:134.

Texas.

Specimens examined from Texas: Lindheimer; "Sandy tributary of Mill Creek," 1839; 1843; No. 275, 1844: Nos. 426 and 427, Victoria, 1845; 1847; No. 425, Victoria, 1848.

P. DRUMMONDII VILLOSISSIMA A. Gray, Proc. Am. Acad. 2:257 (1870). Gray, Syn. Fl. 2:134.

Type locality; "Texas, in the pebbly bed of the Nueces."

A. A. Heller's specimens from Neuces Bay, Neuces Co., March 12, 1894, is doubtfully referred here, notwitstanding its lack of viscosity and its smaller flowers.

ENUIS (A. Gray) n sp.

P. Drummondii var. tenuis A. Gray, Proc. Am. Acad. 8: 257 (1870). Gray, Syn. Fl. 2: 134.

Type locality; "Eastern Texas."

This should have specific rank. It is very distinct from *rummondii* and no intermediate forms have been seen. a much smaller plant, entirely devoid of coarse villous s and only slightly pubescent or glabrate.

pecimens examined from Texas: F. Lindheimer, Victoria, 1845 ral specimens); E. Hall, Hempstead, Eastern Texas, 1872, No. C. Wright, No. 11,964.

†Corolla tube glabrous, not exceeding the calyx; ovules 4-5 in cell.

OEMERIANA Scheele, Linnaea, 21: 752 (1848). *P. macrantha* Buckley, Proc. Acad. Phila. p. 5 (1862). Gray, Proc. Am. Acad. 8:257. Gray, Syn. Fl. 2: 134.

Texas.

pecimens examined: F. Lindheimer, No. 467, Camale Spring, No. 68, San Antonio, 1846; New Braunfels, 1848.

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UNIVERSITY OF WYOMING.

Agricultural College.

NINTH ANNUAL REPORT

. . . OF THE . . .

OMING EXPERIMENT STATION,

LARAMIE, WYOMING.

For the Fiscal Year 1898-99.

Wyoming Agricultural Experiment Station.

UNIVERSITY OF WYOMING.

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NINTH ANNUAL REPORT

... OF THE ...

ING AGRICULTURAL EXPERIMENT STATION.

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hereby submit the ninth annual report for the Wyo-
Agricultural Experiment Station in compliance with
ssional enactment. The report covers the work of
ation during the fiscal year ending June 30, 1899.

ORIGIN AND PURPOSE.

Wyoming Agricultural Experiment Station is the
ment of research of the College of Agriculture of
niversity of Wyoming. Congress in 1887 appropri-
15,000 annually for this purpose, and on January 10,
he Wyoming Legislature authorized the University of
ing to receive this appropriation. The work of
ation is to aid in the acquiring and diffusing among
ople of the United States, and especially of Wyoming,
and practical information on subjects connected with
lture, to conduct scientific investigations and exper-
on the physiology of plants and animals; to inves-
animal and vegetable diseases and parasites; to chem-
analyze soils and water and vegetable and animal
ts; to acclimate grains and grasses, fruits and vege-
to our arid climate and high altitude; to ascertain the
ethods of irrigation, and of retaining the moisture
soil; to find the best breeds of stock, and the best
es of field and garden crops for the various portions
oming; and to carry on any other experiments which
e to benefit our agricultural and grazing interests.

The results of these experiments are published in the Stat Bulletins, which are sent free upon request to residents this State.

BULLETINS.

The bulletins published during the year 1898-99 h been four in number, the title and a brief summary of e being given below. These bulletins have been rather p ular reports of the investigations by the station. Ot more technical papers are published as a part of this rep and are as follows: "Alkali Studies III," "Alkali Stud IV," "Meteorology for 1898." These are detailed reports scientific investigations and observations.

The bulletins are:

NO. 38. CULTIVATED SHADE AND FOREST TREES.

This bulletin contains a report of all the experime in growing shade and fruit tree which have been made the Station. It shows what trees may be expected to ceed in different parts of the State and contains a brief count of some troublesome insect enemies of our trees.

NO. 39. ALKALI STUDIES II.

This is a somewhat popular report of the alkali inve gations in the Departments of Chemistry and Agricult It gives a condensed account of some of the experime which are reported in detail in the technical papers.

NO. 40. THE TREES OF WYOMING AND HOW TO KNOW TH

This report gives an account of all the trees found tive in the State, with such simple descriptions and illus tions as will enable anyone, whether he be a botanical dent or not, to recognize the different species. The Bull shows the value of our forests and the need of conserv them. It appeals to the people to make the home more tractive by planting trees, and is intended to awaken an terest in the subject among the teachers and schools of State.

INDEX BULLETIN B.

This is a general index showing all Bulletins which been issued up to the beginning of the present fiscal and indexing Bulletins 27 to 37 inclusive.

PLANS OF STATION WORK FOR 1899-1900.

he following plans for the season of 1899-1900 have been stated. It will be seen that most of them look to car- g out the new policy of the Station. They were recom- led by the Station Council and approved by the Agri- ural Committee of the Board of Trustees.

THE AGRICULTURIST AND HORTICULTURIST.

- Irrigation investigation.
  - a. Co-operation with the Department in measurements of water on farms.
  - b. Measurements of water used on Experiment Farm.
  - c. Plat experiments, different amounts of water on the same crop.
  - d. Notes on sub-irrigation.
  - e. Evaporation.
- Alkali investigations.
  - a. In the field—Effect of irrigation.
    Effect of green manures.
    Economic plants on alkali soil.
  - b. In the laboratory.
- Soil work.
  - a. Permanent soil plat; same crop year after year.
  - b. Crops with and without cultivation.
  - c. Crops with and without rotation.
  - d. Alfalfa as a fertilizer.
- Cereals.
  - a. Varieties of small grain.
  - b. Plat work including co-operation with the Department of Agriculture with Russian varieties.

5. Forage Crops—Cultivated and native, including operation with the Department of Agricult
6. Potatoes—With fertilizer—second season.
7. Horticulture.
    a. Hardy fruits at Laramie and fruit notes at L der and Sheridan.
    b. Celery (varied treatment).
    c. Garden—small amount of variety work.
    d. Asparagus on alkali and good land.
    e. Pedigreed potatoes.
    f. Native trees and shrubs for decoration.
    g. Floriculture for decoration.
8. Forestry—Co-operative with Division of Fores
9. Notes on injurious insects and collections.
10. Varieties of wheat at Laramie, Lander and Sh dan.

Approved by the Station Council April 6, 1899.

B. C. Buffum,
Agriculturist and Horticulturist.

THE BOTANIST.

1. The continuation of the field work and accumula of data upon the subjects heretofore un taken but as yet not completed. (As g for 1899.)
2. A co-operative study of alkali in its relation to p life.
    (1) The comparative structure of alkali resis and non-resistant vegetation.
        (a) External characteristics.
        (b) Histology.
3. Experiments with promising forage plants.
    (1) For normal soils.
    (2) For alkali soils.

THE CHEMIST.

Effect of alkali on germination of seeds.

Analysis of soil and alkali.

Analysis of alkali-resisting plants.

Analysis of irrigation water.

THE GEOLOGIST.

Completion of the preliminary bulletin on the artesian basins of the State.

The origin of alkali.

  (1) The geological location of these salts and their relation to the various terranes.
  (2) The way alkali finds its way into the soils.
  (3) Preventing further accumulation if possible.

Wind erosion and its relation to soil formation in the arid districts.

To complete the preliminary work on the birds of Wyoming and arrange notes for publication.

THE PHYSICIST AND METEOROLOGIST.

Capillary movements of water in soils.

Evaporation from soils.

Continuation of the work of making observations and co-operating with the State and United States Weather Service.

Observations on the precipitation from as many places in the State as possible.

Observations upon the direction and force of the air currents at Laramie.

Study of terrestrial radiation and sunshine.

Report of the Station Council.

REPORT OF THE DIRECTOR.

The writer of this report, E. E. Smiley, succeeded F. Graves as President of the University of Wyoming and I rector of the Agricultural Experiment Station, July 1 1898.

GOVERNMENT.

I deem it best to say somethings concerning the gove ment of the Station, as this seems to have been nowhere e plained in previous reports. The government of our Ag cultural Experiment Station is vested in the Trustees of t University and the Agricultural Executive Committee the Board, whose names appear on a preceding page. T officers of the Station are a director and a secretary, wh together with the heads of the different departments in b any, chemistry, geology, physics and meteorology, comp the Station Council; which body passes on all matters p taining to Station work in the way of experimentation a research, and makes recommendations to the Agricultu Executive Committee. All plans of work by the heads departments are first discussed and accepted, modified rejected by the Station Council; this system insures the operation of the staff of Station workers and prevents sc tered work and misapplied effort. Again, all bulletins p lished by the Station are first read before the Station Co cil and each member is free to criticise any questiona point of fact, extravagant statement or the general arran ment of the matter; and finally the bulletin may be eit adopted and recommended to the Agricultural Execut Committee for publication, or it may be returned for vision, or be entirely rejected. Such has been the gen policy governing the Station since its organization; and fact that the workers have been a unit force, and so h

a combined atack on the important agricultural prob-
rom all sides at the same time, has contributed largely
ir success heretofore.

OBJECT.

ne study and research of the Station are made as prac-
s possible, and have to do with the problems which in
inion are of most importance to the farmers of the
For example, the subject of irrigation and the alkali
m have been given much attention. At the present
o far as we can we are co-operating with the Depart-
of Agriculture at Washington in the new irrigation
being done under the direction of Mr. Elwood Mead,
as been for a number of years the efficient State En-
of Wyoming, and is now connected with the office of
ment Stations. The results of our work are being
ned from time to time. The carefully prepared bulle-
ased as they are upon as thorough work as we can do,
ered to the people with the belief that they contain
g but reliable information, upon which the greatest
ence may be placed.

e widely scattered population of the state has made
st impossible for the Station to come into direct con-
th our farmers. The farming communities are natu-
ocated in the places most favorable to agriculture,
sometimes separated from one another by mountain
and long distances; and with the funds at our com-
and the small number of our Station workers it has
seemed impracticable to do any general farmers' in-
work. However, when the time comes that it is pos-
r us to engage in this kind of work, we shall be glad
rtake it; because we believe it will prove most valu-
bringing the farmers and our Station into closer
with each other. The Station workers would then
better acquainted with the farmers' needs, and the

information offered by the Station could be better brough
before the attention of the farmers.

FARM.

In July the Station was inspected by Dr. A. C. True
Director of Experiment Stations, who made some valuabl
suggestions in regard to the enlargement of our Experimen
Farm at Laramie, in order that irrigation experiment
might be more extensively carried on. Accordingly ou
original forty acres have been increased by a donation of a
additional eighty acres of land, with water right for th
same, from the Wyoming Central Land and Improveme
Company. This land is presented to the Station to be hel
so long as it used for experimental purposes, and fills a lon
felt want in supplying land for irrigation on an adequa
scale to furnish results of value to the arid west. This la
has been fenced and forty acres plowed and put into cro
this year.

The Station buildings are a small five-room cottage,
tool shed, and a shed used as a barn at the farm; and a ba
and green-house on the University grounds. The farm
well equipped with implements and all needed machine
The great need of the Station is a good-sized barn in whi
to store farm implements and grain, and to provide room
threshing and winnowing of seeds indoors. With only
amount which can be used each year for building purpo
from the Hatch fund ($750) it is not possible to build m
than in a very small way, and it would seem that the St
will need to make some provision in the near future
more commodious buildings for the Station. In case w
is ever begun in animal industry, it will be necessary to
to the buildings at considerable cost. When the vote of
last Legislature shall have been carried into effect and
present buildings in Laramie now occupied as a peni
tiary shall have been abandoned for the new state build

ıwlins, will it not be practicing a wise economy for the Legislature to turn over the old grounds and buildings to the State Agricultural College of the University of ming?

SUB-STATIONS.

The Saratoga and Wheatland farms have reverted to riginal donors and the permanent improvements on farms have been sold for what they would bring. The ance farm is still held by the University, but it has not ed possible to rent the place and it is standing still out cultivation or the care it should have. This farm d be rented or disposed of as soon as possible; for it is oing to be creditable to the institution to have a farm t or any other section of the state growing up to weeds with the buildings and fences fast becoming dilapi-.

The Lander farm has been rented to Mrs. J. S. Meyer, has paid a small cash rental in advance; and who s to seed down ten acres to alfalfa, and to care for the keeping notes on the same. It is with regret that we d the death of Mr. J. S. Meyer, who has been connected the Station since its organization as Superintendent e Lander farm.

The Sheridan farm has been rented again to Mr. George elter for a small cash rental with the understanding e is to do certain co-operative experimental work, fur-reports of the fruits growing on the place, and keep the s and buildings in repair.

t is hoped that at least the farms at Lander and Sheri-ay in time receive sufficient support from the state to up valuable experimental work in those places. In a er of states, notably California, the state legislatures de funds for the support of several outside Station ; and it would seem that a small amount appropriated his purpose would bring good returns to the people, and besides would show our good faith in receiving the generous donation from the federal government through the Hatch fund.

BULLETINS.

During the past year an important change has been made by the Station in the matter of its publications. It has been decided to make the bulletins that are published for distribution more popular in their nature, and such as will better meet the demands of our own farmers by giving them practical information. Already this change seems to have met with general approval. These more popular bulletins as they are published are not now sent to all the names on our mailing list throughout the United States but they are widely distributed among the people of the state of Wyoming. It should be said, however, that the bulletins will finally reach every name on our official list for the reason that they will be bound in with our annua report, which is usually sent the rounds. Consequently th purely technical papers will be published hereafter only a part of our annual report, and will not be for general distr bution as in the past.

A description of our laboratories in the several depart ments of physics, chemistry, botany, horticulture and agr culture, has already been given in connection with our ac count of the Agricultural College on a preceding page.

Our library is fast growing. All bulletins sent us from other stations are saved, and as complete sets are obtained in sufficient number to make a volume they are bound i cloth.

REPORT OF AGRICULTURIST AND HORTICULTURIST.

The bulletins issued from this department during th year were No. 38, "Cultivated Shade and Forest Trees" an jointly with the department of chemistry bulletin No. 3 "Alkali Studies II." A bulletin has also been prepared f

tation giving the results of a three year test in subsoil-
ut its publication has been deferred until September.
irrigation records and notes which have accumulated
1892 have been collated; the amount of water used by
tations at Laramie and Wheatland and on the farm of
. Sigman near Laramie has been computed from the
ter sheets, and a bulletin on "Duty of Water" has been
red for the U. S. Department of Agriculture.

he teaching in the agriculture college and university,
luties as Vice Director make it possible to devote only
of the time to research work. Heretofore it has been
ically impossible to keep ahead of the mass of notes
ecordswhich accumulate from year to year. The past
the position of students in the courses has been such
the teaching has not been as heavy, consisting, as it
f two hours in the fall and winter terms and one hour
e spring term, so special attention was given to work-
p our records, and putting the notes in more perma-
and available form. The crop record for 1898 is not
leted but as a whole the notes have been more nearly
ght up to date than for a number of years past. Mr.
eld devoted the larger part of his time during the win-
onths, to this work which consisted of sifting out and
ging the notes taken in day books, computing areas
ields, and assisting with the computations of flow of
, to determine the amount used on different crops.

he fact that the field of labor nominally covered by
partment is too broad has long been recognized. The
ment of a man who claims to be a specialist in several
hes, naturally falls under suspicion among scientists
o relieve the odium of such a position it would seem
o state briefly the conditions under which we labor,
enable me to look after several departments and do
ically nothing in more than one or two lines of inves-
on. Agriculture in Wyoming is still very new com-

pared with that of older states. The population is scattered and the range stock industries are still paramount to al others. There are comparatively few calls on the time o the station workers from other parts of the state and eac head of a department may follow his investigations wit comparatively little interference from extraneous sources As yet the station workers have not been called upon to d any farmers institute work. During the history of the station but one paper has been prepared for a farmer's institute and the writer of the paper did not present it at th meeting. True there is considerable correspondence wit farmers on the subjects of importance to them but up to th present time few inquiries have been received which calle for extended investigation or experimentation before the could be answered.

As agriculturist and horticulturist I have charge of al the work which falls to those departments. A claim tha I am a specialist in all the divisions of agriculture and horticulture would indicate a pitiable state of ignorance, t those who realize what such a statement would mea However I am able to keep these departments alive by onl giving attention to those things which promise to be o greatest immediate value to our farmers. But little horticulture exists in our state. There are probably not to exceed one hundred acres planted to fruit of all kinds an nothing is done of commercial importance in fruit growin On account of the very newness of things there are no serious insect enemies, and as yet what insects of economic importance have appeared are well understood and easy t combat. On account of this same newness, and the natur fertility of arid lands the application of fertilizers has n required attention and even crop rotation is only beginnin to receive attention. In agriculture we have given almo no attention to any phase of live stock or dairy work. Th salts in the soil, irrigation and cropping are the subjec have received special attention and while the work-rce has been small we believe something is being ac-ished of immediate value to our farmers. The teach- the agricultural college and university requires con-ble time and interferes with the original research work than any other required-duty.

plans of work for last season as given in the eighth l report were fully carried out, something being done h line indicated. Last season was the third year of b-soil experiment, a report of which will be made in xt station bulletin. The permanent soil work, as es-hed for several years, consists of two plats, one of is planted to grain each year and the other planted in nt crops, following a four years rotation. The grain beginning to show the effects of planting to the same ear after year. Either the land or the seed is running d to determine which is the case a change of seed will ed.

ur study of varieties of small grains has probably arried out as far as will be profitable. As many varie- wheat, oats and barley as could be obtained have rown in small amounts for several years. The work een expensive as each individual variety requires its pecial care and complete record and all have to be l and selected to keep the seed pure. We believe we lect those varieties of greatest promise for this state ow in larger fields for a few years to obtain sufficient t of seed to give our farmers a start in them. The promises to be of considerable value. Our high al- and unusual conditions of soil and season make the to be grown, and its adaptability, of considerable ance. Earliness is a prime necessity in both oats and and a shortening of the necessary season for grain ture, of a week or ten days, insures plump, heavy instead of a frosted, shrunken, inferior product.

Perhaps the most important of all our work in croppi is that with forage plants. The amount of land which c be irrigated is small compared with the land which m always serve as pasturage in this state. Such conditio must ultimately fix a system of mixed farming in wh stockraising will be the main object and the growing of h and other stock food on the irrigated land undoubtedly w always be the principal part of our plant production. W then can the station do which will be of greater value to t state than to demonstrate how two blades of grass can made to grow where only one grew before? So far as have determined the forage which will resist drouth bet than any other is the Sanfoin or Esparsette. The o which resist alkali best are the White Sweet clover a English rape and the best all-round hay crop even at t altitude of the experiment station (7,200 feet) is alfalfa. falfa produces from two to four times as much as any i gated native grass. It solves the foxtail or any other we problem and keeps up the land so large crops of grain potatoes can be raised without other fertilizing. The n Turkestan alfalfa introduced by the United States Depa ment of Agriculture seems to stand the winters and drou better than the variety generally grown. During the p winter none of the Turkestan alfalfa died while all the ot fields suffered more or less. At Laramie our average yi of alfalfa per acre, for three years past, has been over th and one-half tons and plats in which the stand has b best yield over four tons of cured hay. On account of t short season we can only cut alfalfa twice, and the seco cutting is usually but a partial crop.

The flat pea (Lathyrus sylvestris) grows well and se perfectly hardy, but there are two or three serious obj tions to it. First, it takes three or four years to get it produce a heavy crop; second, the roots are so tough a deep seated that it is almost impossible to get it out of ınd third, we have been unable to make stock eat the This last objection to the flat pea is also the serious th White Sweet clover, though it is claimed by people h and in Mississippi that stock can be educated to eat clover hay. We have thought the hairy vetch a promıay crop but nearly all of it was killed by the past seinter.

ıe alkali and irrigation investigations have been of elsewhere. Co-operative tests with sugar beets iscontinued this season as we believe the station has ıll the work with sugar beets which circumstances ıt at present. Our experiments with fruits at Laraove that strawberries, currants and dewberries can be for home use. Other fruits have not succeeded. The er experiment carried out last season, using potash nd barnyard manure for potatoes, did not give results we believed were entirely trustworthy and the same vere planted to potatoes again this season. It seems e land is already so rich in sulphates and chlorides of and magnesium that adding sulphate or chloride of um diminished instead of increased the crop. Even ıpplications of barnyard manure greatly increases the ıt sodium nitrate apparently does not produce a like This indicates that the land needs humus rather reater supply of nitrogen in any other form.

st year we planted about three acres of land with rees of Scotch, Austrian and Bull pines furnished by vision of Forestry of the Department of Agriculture. small percent of the trees lived through the winter larger part of the land was put into other crops this It is unlikely that the growing of trees for any other e than shade and ornamentation will ever pay here, do not expect to carry out any further experiments ıem unless it be in a very small way.

The equipment of the Station has been materially i creased and improved during the year. The increase in t size of the experiment farm enables us to carry on so irrigation experiments on a practical scale. Eleven acr of the new land have been used for an investigation of t amount of water needed to produce a maximum crop. Th investigation will probably be continued through a numb of years. The old farm is all used for small plat work a alkali studies so it was impossible to branch out as wished in the irrigation work. The new land, however, ample for all our needs. We will not bring all of it und cultivation for some time. To the equipment have be added a Fairbanks and More gasoline engine of four-hor power, which is used for threshing and grinding gra Farmer's No. 3 grain and bone mill, a Deering Ideal mowi machine, a new steel plow, and a twelve-foot windmill. pumping packer was put into the well on the farm but yet good water has not been obtained. Among the perm nent improvements made may be mentioned finishing t upper floor in the cottage on the farm and adding a porch the front. A small potting and store house was built at t east end of the greenhouse. A new germinating chamb was purchased for further study of the effect of alkali sa on seed germination. The greenhouse furnishes very go laboratory facilities for the department. Some new irri tion instruments have been purchased, including a curre meter, two water registers, and a Brown hydrostatic level

More room is needed on the farm in which to shelter i plements. The only way the machinery can be put und cover now is to take it to pieces so it may be stored i small space. This prevents keeping it under cover while use now and even during the summer, without a great d of extra time and trouble. An adequate building should provided as soon as possible in which to store tools a ıd to furnish room for cleaning grain and seeds dur· winter.

have been fortunate in securing this year Mr. E. as farm foreman. It has been difficult to obtain telligent help for the farm labor, and Mr. Sigman wn himself both capable and energetic. Mr. Fair· been efficient and faithful, taking a great interest work. The success of the work depends in no small on such assistance. The man who is merely work· is daily wages is not apt to take that interest in his hich makes him efficient and indispensable to the em· who would have the best service. These men not e the work but feel their responsibility and have ons to make which mean success in life. Instead of eight or ten hours a day their hours of labor are all rs out of twenty-four that they are able to work. little danger of getting overpaid for such services, hoped they may be kept in their present positions.

have obtained much help during the year through labor. A student has acted as stenographer and er in the office, the insect collection has been over- nd duplicates in recent collections brought together, larger part of the year the green house has been r by student help.

t July I attended a conference of irrigation experts, er, on invitation of the officials in the Department ulture, to discuss the work in irrigation to be under- the department. In September I attended the Na- rigation Congress in Cheyenne and in November I ted the experiment station at the meeting of the n Association of Agriculturual Colleges and Ex- t Stations held in Washington.

REPORT OF THE BOTANIST.

Of the several lines of work projected for the year closing only a few have received any considerable attent There is so much to be done in each that only one or two be successfully pursued at any one time. Data are be accumulated on various subjects but to bring them point warranting publication means much special attent

One bulletin, "The Trees of Wyoming and How to K Them," has been issued this year as No. 40 of this Station is a part of this report.

The botanical survey of the state is progressing as idly as other work will permit. During the summer of the botanist spent several weeks in study at the Missouri tanical Garden, St. Louis, but during his absence field was prosecuted by Mr. Elias Nelson. As a result of th forts in this direction during the past few years the sources of the state are becoming fairly well known. pecial attention has been given to the indigenous fo plants and much information, which it is hoped may b service, has been secured concerning the distribution abundance of these.

Since the last report, the writer's investigation of "Flora of the Red Desert and Its Forage Resources" been published by the United States Department of A culture, being issued as Bulletin No. 13 from the Divisio Agrostology.

The abundance, distribution and economic signific of the fungi affecting native and crop plants is still a sub of inquiry. While not of so much significance here a some other states yet it is of interest now and will bec more so as agricultural interests are developed.

Besides the plants of direct economic significance survey of the state is bringing to light many of much gen interest, among them many new species. As rapidl possible these are being described and published, there n issued since July 1, 1898, the following papers: V, VI and VII in the series "New Plants from Wyo- This series is appearing in the Bulletin of the Tor- anical Club, the foregoing papers having been issued July and October numbers of 1898 and the January, nd May numbers of 1899 respectively. Other papers en prepared and are in the way of publication but t find space for some months to come.

tain genera are so abundantly represented in this s to make them to a degree the characteristic plants lora. Some of these have received much study and, unt of the new species each includes, have proven of h interest as to warrant the preparation of special upon each. Just issued in the June number of Ery- "The Western Species of Aragallus." The following ourse of publication: "Some Rocky Mountain Chrys- i;" "New Species in Oreocarya and Its Allies;" Species of Tetraneuris and Its Allies."

erence may here also be made, as bearing upon the al survey work, to the "Revision of the Western merican Phloxes," by Mr. Elians Nelson. It is pub- s a part of the Ninth Annual Report of the Agricul- llege, which is bound herewith and to which atten- called.

ong the subjects of investigation the present season forage plants of northwestern Wyoming, including tone Park and the adjacent Forest Reserves.

REPORT OF THE CHEMIST.

vork of the chemist during the year has been prin- confined to the study of the effect of alkali on the ion of water by seeds and their germination, the re- which are published in Studies III and IV in this In addition to this a number of soil samples taken from different depths of the Laramie Farm have been alyzed to get a better idea of the movements of the alk under irrigation.

REPORT OF THE GEOLOGIST.

During the year there were collected considerable d pertaining to the various lines of investigation. The f lowing work is under way:

The Artesian Basins in Wyoming.

Wind Erosion and its Relation to Soil Making in Arid Region.

The Origin of Alkali.

The Birds of Wyoming.

The bulletin on the Artesian Basin in Wyoming is s in course of preparation. It has been utterly impossi owing to the rush of work, to make the geological maps section and to work up my notes for the bulletin. It will when printed, quite an extensive discussion of the subject have also taken valuable notes in wind erosion at all poi visited in the state.

Since the state has concluded to take up the sub of alkali and to work out all the problems in connect with it in Wyoming, I have been assigned the subject of Origin of Alkali. I realize that it is a great problem to dertake to solve, but there is not a better field to wor than Wyoming to accomplish this end. During the com season I expect to add some valuable data pertaining to subject.

REPORT OF THE METEOROLOGIST AND PHYSICIS

Observations in the Meteorological Department been taken of the relative humidity, maximum and mum temperatures, pressure of the air, rainfall, snow velocity and direction of the wind, evaporation, percen of sunshine, and temperature of the soil at various dept

account of the interference of the University build-
ith the air current, especially when the wind was
g from the west, the steel tower on which are the
meter and wind vane was moved to a distance of 800
ay from the buildings.

l observations, except amount of rainfall and snow-
e taken each day at 7 a. m. and 7 p. m.

the physical department the following are some of
oblems which are being investigated as rapidly as cir-
nces will permit:

pillary movements of water in soils.

aporation of moisture from the surface of soils.

ddling of soils.

TREASURER'S REPORT.

UNIVERSITY OF WYOMING.
AGRICULTURAL EXPERIMENT STATION,
LARAMIE, WYOMING,

. . . In Account With . . .

THE UNITED STATES APPROPRIATION, 1898-99.

DR.

ipts from the Treasurer of the United tes as per appropriation for fiscal year ing June 30, 1899, as per Act of Congress roved March 2, 1887....................$15,000.00

CR.

ries	$ 5,090.00
or	2,735.99
lications	1,170.02
tage and stationery	472.96
ight and express	234.71
t, light and water	887.61
mical supplies	515.87
ds, plants and sundry supplies	260.38
tilizers	8.35
ding stuffs	34.92
rary	79.90
ls, machinery and implements	705.23

Furniture and fixtures		**34**
Scientific apparatus		**79**
Traveling expenses		**84**
Contingent expenses		**6**
Building and repairs		**75**
Total...............................	**$15,000.00**	**$15,00**

We, the undersigned, duly appointed auditors of
corporation, do hereby certify that we have examined
books and accounts of the University of Wyoming Agric
tural Experiment Station for the fiscal year ending June
1899; that we have found the same well kept and classi
as above, and that the receipts for the year from the tre
urer of the United States are shown to have been $15,
and the corresponding disbursements $15,000; for all
which proper vouchers are on file and have been by us
amined and found correct, thus leaving no balance on ha

And we further certify that the expenditures have b
solely for the purposes set forth in the Act of Congress
proved March 2, 1887.

Signed: Melvile C. Brown,
Henry L. Stevens,
Auditor

Attest:
Grace Raymond Hebard,
Secretary.

SUPPLEMENTARY STATEMENT.

	Fees	Farm Products	Miscel-laneous.	
DR.				
To receipts from other sources than the United States for the year ending June 30, 1899........	$70.90	$100.00	$300.00	$47
CR.				
Scientific apparatus			123.00	
Buildings and repairs.......	70.90	100.00	177.00	
Total..................				$47

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KALI STUDIES, IV, by E. E. Slosson.
IEOROLOGICAL REPORT FOR 1898, by C. B. Ridgaway.
LLETIN NO. 38. CULTIVATED SHADE AND FOREST TREES, by B. C.

LLETIN NO. 39. ALKALI STUDIES, II, by E. E. Slosson and B. C.

LLETIN NO. 40. THE TREES OF WYOMING AND HOW TO KNOW
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ALKALI STUDIES, III.

BY B. C. BUFFUM.

LISHED AS PART OF THE NINTH ANNUAL REPORT OF THE
WYOMING AGRICULTURAL EXPERIMENT
STATION.

JULY, 1899.

LARAMIE, WYOMING.

ALKALI STUDIES, III.

ninating Experiments With Alkali Salts.

BY B. C. BUFFUM.

That concentrated solutions of the salts commonly d in soils do retard germination was demonstrated ublished in Bulletin No. 29 of this station. Since that the subject has been given considerable attention in tation and by others engaged in scientific research. The riments here reported were carried out by Mr. W. H. ield, assistant in this department. A resume of a part e work was given in Bulletin No. 39, which is bound this report. The importance of the subject and the cer- y that future references will be made to this work, will valuable a detailed account of the experiment and the ts obtained.

Alkali, as commonly known, consists of the several sol- salts of the soil, which accumulate in sufficient amount come noticeable in white incrustations on the surface, their effect on water, soil, and vegetation. Our first inating tests were made with the associated salts as occurred in the soil of the experiment farm. The nt of any one of the salts making up this compound s widely in different places and undoubtedly at differ- imes in the same place. Generally the salt making up arger portion of the alkali is sodium sulphate or mag- m sulphate, but in places it is sodium chloride or as times occurs in this state, it may be sodium carbonate. der then to arrive at definite conclusions in regard to ffect of alkali it seems important to study the relative effect of each salt. This experiment shows that each s differs widely from the others in its effect on seed germi tion and plant growth, and has led to further study of t reason for such effects. The study was continued by P fessor Slosson, who made a preliminary report in Bulle No. 39, and reference is here made to his paper, "Alk Studies IV," also published as part of the Ninth Ann Report. The following experiments are reported as th were written out by Mr. Fairfield, with slight modificati and changes in arrangement:

EFFECT OF DIFFERENT SALTS ON THE GERMINATI OF SEEDS.

To determine the effect of each salt which makes up alkali of the arid region, seeds were germinated in soluti of varying strengths of sodium chloride, sodium sulpha sodium carbonate and magnesium sulphate. The two ch points that the test was intended to determine, stated brie are: First, the relative effects of different percents of same salt on the germination of wheat, rye, and Wh Sweet clover (*Melilotus alba*); second, the relative effect the same percent of the different salts on the germination these seeds. It was thought that the osmotic pressure the salt solution might influence the imbibition of water a account for the retardation of germination. We had p viously found that concentrated salt solutions prevented rapid imbibition of water.* An article in the Botanical zette for December, 1897, on "The Relation of Nutrient Sa to Turgor," by Copeland, suggested to the chemist t osmotic pressure might account for such effect rather th any physiological action of salts on the plant tissues. throw light on this point a series of sugar solutions w also used, as the osmotic pressure of sugar is comparati low.

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*See Bulletin No. 29, P. 235.

olutions containing 0.1, 0.4, 0.7, 1.0, 2.0, 3.0, 4.0, 5.0, 7.0
0 percents of each of the salts named and also of sugar
used to germinate the seeds. Fifty seeds of Chili
, Spring rye, and White Sweet clover, which had been
lly hand-picked and counted, were tested in each of
lutions containing the above percents of the salts and
, and a check was carried out in pure water.

OUTLINE OF EXPERIMENT.

tock solutions of the salts to be used as well as of
were made so that, when everything was ready, as
time as possible might be used in converting the solu-
nto the various strengths desired. Certain quantities
salts of sodium sulphate, sodium carbonate, and mag-
n sulphate were dried by heating to a red heat and
g them at this temperature for a short time. The so-
chloride was dried at a little lower temperature. The
solutions were made up as soon after the salts were
as possible. Granulated sugar was used for the sugar
ns.

me little time was spent in determining the best
ating device. The great difficulty to be overcome in
g out the test was the question of evaporation. This
not only change, quite rapidly, the strength of the so-
, but as the seeds must of necessity be at or near the
e, they would be surrounded continually with stronger
ns. The first method adopted was to lay the seeds be-
two pieces of rather fine cheese-cloth and float them
k in plates so that the upper surface of the cork carry-
e cloth would be about even with the surface of the
It might be well to state here that this first entire
ation test, carried on in the greenhouse, was con-
for fourteen days, careful observations being taken
ay on the number of seeds germinated, and every pre-
taken to keep the conditions uniform. After carry-

ing the experiment this far it was evident from the small number that had germinated that the seeds were in unfavorable conditions. After the first few days of the experiment the corks became saturated, lost buoyancy and sank lower, causing the seeds to be surrounded with the solution. The fact that the seeds were under such unfavorable conditions for germination made the results obtained, though comparable to a certain extent, rather unreliable. The test was therefore abandoned and was not begun again until some check tests were made to determine a method of procedure which would furnish conditions least adverse to the ready germination of the seeds, but which would still reduce the effect of evaporation to the least practical point. The following table gives the results obtained from a germination test in water under the different conditions named:

Wheat.				*Rye.*			
Number of days from beginning of test.	Fifty seeds between cloths floated on cork.	Fifty seeds between cloths on inverted saucers in the light.	Fifty seeds between cloths on inverted saucers in the dark.	Number of days from beginning of test.	Fifty seeds between cloths floated on cork.	Fifty seeds between cloths on inverted saucers in the light.	Fifty seeds between cloths on inverted saucers in the dark.
	Number germinated.	*Number germinated.*	*Number Germinated.*		*Number germinated.*	*Number germinated.*	*Number germinated.*
1				1		1	17
2	5	2	12	2	15	27	45
3	8	5	20	3	22	39	46
4	10	7	27	4	27	44	
5	No more germinated.	19	34	5	28	45	
6		24	36	6		48	
7		26	40	7			

In the table it will be noted that, with one exception the seeds between cloths placed on the inverted flower-po saucers germinated much more rapidly and completely tha those placed between cloths floated on cork. The marke difference in the number germinated in the dark and in th light in the case of both kinds of seed is of interest.

So in beginning the experiment again two larg were arranged with shelves to hold the plates. All s in the boxes were stopped up to shut out the light as as possible. These boxes were placed on the center of a double-span greenhouse, on sand which was kept what moist throughout the experiment. Granite iron in pieplates were used to hold the solutions, the tin having previously received two coats of asphalt var- n the inside to prevent rusting. The cloths which had used in the previous tests were thoroughly washed in ater, rinsed, and then boiled for ten minutes. The were also thoroughly washed. Saucers for five-inch -pots were washed, turned upside down, and the cloth l on them. Solutions of the required strengths were up from the stock solutions on hand with the excep- f sugar, which was made fresh, the stock solution hav- ollected some impurities. The weight of each, to- r with the inverted saucer, etc., was taken as the solu- were added and marked permanently on the outside of ates. The plates could be readily weighed at any time d and enough water added to bring back to the initial t, thus compensating for any loss by evaporation and eeping the solution at practically the same strength. of Chili wheat and Spring rye had been carefully selected, only perfect, plump, and as nearly uniform ls as possible being taken. These had also been ed and fifty seeds of each been placed in separate bot- o that all the seeds were placed between cloths at the same time. Fifty seeds were used in each test. first experiment seeds of White Sweet clover were on account of the apparent ability of this plant to h in alkali soils. But though great pains were taken mature seed of last season's growth, not more than r three percent germinated under the most favorable nstances, so in the second experiment these seeds were t and only wheat and rye were used. On February

26, between 1:30 and 4:30 p. m., the seeds were placed on the cloths which were laid over the inverted saucers. One end of the cloth was allowed to project farther than the other and this was now folded back over the seeds. This, therefore, left the seeds with one thickness of cheese-cloth between them and the saucer and one thickness over them. The edges of the cloth dipped into the solutions. The tops of the saucers were about a quarter of an inch above the surface of the solutions. The plates were weighed occasionally during the test and enough water was added at these times to bring them back to their original weight, but the evaporation was not great. Once or twice a day the cloths which contained seeds were dipped into the solutions. On March 16 the experiment was stopped and the final observations were taken. This carried the experiment through eighteen days.

The number germinated was carefully observed. The seeds were removed as fast as they germinated. Complete notes were kept on everything which might influence the results in any way, such as the time of the day each plate was examined, and variation in the condition or appearance o the seeds on any particular plate, etc. In the following tables, the number germinated each day, beginning the first day after the seeds were planted, is given. The results have been tabulated in this way so that they may be more easil compared. Whenever blank spaces occur in the tables the indicate that no seeds were germinated that day. To determine the variation in the germination of different sets o fifty seeds, due to their vitality, etc., two plates were use with simply water. An average of the results also gives more reliable check for comparison. The results of the tw tests run in water as well as the arbitrary average taken ar given in the first two tables. The reason for taking an arbitrary average rather than an absolute one, is that it ma be expressed in whole numbers.

e giving the results from two tests in water, show- ınavoidable variations in the number germinated ıe difference in the vitality of the seeds, etc., and e arbitrary average used in the following tables:

Wheat.			*Rye.*			
Plate No. 1.	Plate No. 52.	Arbitrary average.	Number of days from beginning of test.	Plate No. 1.	Plate No. 52.	Arbitrary average.
	2*	1	1	16	31	24
12	18	15	2	46	47	46
23	26	24	3	47	48	47
27	31	29	4			
32	32	32	5			
34	35	34	6			
36	37	37	7			
			8			
40		39	9			
41		40	10			
42	39		11			
44		41	12			
	40	42	13			
		43	14			
45	41	44	15			
			16			
			17			
	43		18			

seeds were barely germinated when the observations were taken for the first day.

following charts and tables give the relative effects me percents of the different salts used in the germ- f wheat and rye. Charts of the rye have not been ause the seed germinated so rapidly. In the water eeds that had sufficient vitality to germinate at all owing in three days. The fact that wheat germin- nuch more slowly in all the solutions gives an op- for the study of the relative effects of the different in graphic form in the charts. The variations are t irregular, but this may be due to different causes, ipal one probably being the difference in the vitali- fifty seeds in each test. In the charts the abscissas the number of days from the beginning of the test and the ordinates the number of seeds germinated. T line representing water is the same through all the char being the check.

In the chart represting the 0.1 percent solutions the dium carbonate curve makes a marked variation from water curve, there being twenty-four seeds germinated second day, against sixteen in water, and on the followi days the difference in the number germinated remains marked.

In the 0.4 percent chart it will be noted that, from fourth day on, all the salt curves precede the water curv The fact that the seeds in all salt solutions at this perc germinated quicker than in water, regardless of the da variations, shows a stimulating effect which is of interest

That a small amount of alkali does aid in the germi tion of seeds is substantiated by some of the results given the report of the germination experiment in Bulletin No. of this Station. Referring to that report it will be seen t seeds germinated more readily in soil containing a sm amount of salts than in leached soil. It is very interest that a small amount of salt should facilitate the process germination. Is the salt a factor in the process of conv ing the plant food stored up in the seed into an availa form for the use of the growing embryo? Does the prese of the *very* small amount of the salts influence the turgo the cells of the germinating seed and thus cause this be ficial result? Copeland, in his article, "The Relation of trient Salts to Turgor," in the December number of the tanical Gazette for 1897, states that potassium increases turgor in the cells of the plant. He does not believe t sodium has an equal effect, but it has occurred to me t the very small amounts of the salts used in this experim might so influence the turgor in the seed as to produce marked effect on germination. No marked stimulat effect was produced by sodium chloride.

In the 0.7 percent solution chart the curves remain somewhat close to the water curves, though the sodium carbonate drops down a little. This indicates that, with the exception of the latter, solutions of the salts at this percent have no marked effect on the germination.

The 1 percent solution chart indicates that sodium carbonate at this strength retards germination decidedly.

In the 2 percent, 3 percent, 4 percent and on up to the 9 percent solution charts, the retarding effects are shown to increase very rapidly.

It is apparent from the experiment that the retarding effects of the different solutions are in proportion to their osmotic pressures. Professor Slosson has worked out the osmotic pressures of 1 percent solutions of the salts and also of the sugar and has kindly furnished them. They are as follows:

"1 percent sodium chloride equals 7.4 atmospheres.
1 percent sodiuum carbonate equals 4.3 atmospheres.
1 percent sodium sulphate equals 3.9 atmospheres.
1 percent magnesium sulphate equals 2.8 atmospheres.
1 percent sugar equals 0.7 atmospheres."

If the osmotic pressure of the different salts is the cause, or one of the principal causes, of the retarding effect they exert, the curves showing the respective effects of the different salts should arrange themselves in the order of their osmotic pressure. It will be seen at a glance that sodium carbonate, from the 1 percent solutions up, has a greater retarding effect than any of the others, which would not be the case if caused only by the difference in osmotic pressure. This is without doubt due to its caustic effect on the seed, which would be considerable in the solutions containing the higher percents of the salts. This fact, that sodium carbonate is alkaline and that the other salts used are neutral, puts it at once in a different category. Then if we confine ourselves to the other salts we find that from 3 percent up they arrange themselves in the order of their motic pressure. Below 3 percent the relative retarding fect of the salts seems to be quite irregular, probably cause the osmotic pressures are not great enough to ma a marked difference. The 5 percent solution chart sho variation in this order, the sodium sulphate and magnesi sulphate curves cross, but owing to the fact that the or is maintained in the higher precents this variation proba is not important. Solutions of sugar are used in the exp ment in order that we might be able to compare the effect this substance on the germination of seeds with the effe produced by the salts used. It is probable that any reta ing effect sugar might be found to have, would be due to motic pressure alone. Sugar has a low osmotic press compared with the salts used but when the solution is ficiently concentrated, (from 5 percent up) its curve dr below that of water. It is of interest to compare the 9 cent sugar curve with the 1 percent sodium chloride and 2 percent sodium sulphate curves, as the osmotic pressur each of the solutions is nearly the same. There is a mar difference in the osmotic pressure of sodium chloride sodium sulphate, that of the former being nearly twice t of the latter. In the charts there is an analagous differe in their respective curves in the higher percents. Betw sodium sulphate and magnesium sulphate there is not much difference in the osmotic pressure, and in the ch there is not the difference in their curves. These results dicate conclusively that the retarding effect of a salt s tion on the germination of seeds is in direct proportio its osmotic pressure when the solutions are strong.

TABLE I.—*Rye in Sugar.*

howing number of seeds germinated each day in the different percents.

Water.	0.1 percent.	0.4 percent.	0.7 percent.	1 percent.	2 percent.	3 percent.	4 percent.	5 percent.	7 percent.	9 percent.
24	28	18	28	21	16	28	7	16	4	15
46	46	45	50	47	40	47	42	46	43	45
47	48	47		48	43		44	48	47	48
		48			44				48	
								49		
									49	
						48				

TABLE II.—*Rye in Magnesium Sulphate.*

howing number of seeds germinated each day in the different percents.

Water.	0.1 percent.	0.4 percent.	0.7 percent.	1 percent.	2 percent.	3 percent.	4 percent.	5 percent.	7 percent.	9 percent.
24	19	29	27	19						
46	40	45	47	45	34	42	19	15	8	
47	46	48	50	47	40	46	27	26	17	
					41		30	32	24	21
					42		33	33	25	24
										26
				48						
							34		26	
										27
										28
									27	

TABLE III.—*Rye in Sodium Sulphate.*

Table showing number of seeds germinated each day in the diffe percents.

Number of days from beginning of test.	Water.	0.1 percent.	0.4 percent.	0.7 percent.	1 percent.	2 percent.	3 percent.	4 percent.	5 percent.	7 percent.
1	24	30	17	27	13	4				
2	46	47	47	46	40	32	14	3		
3	47	49	48	48	43	35	22	15	8	
4					45	38	24	25	21	11
5							27	27	22	13
6						39		29		
7								30	23	
8										
9								32		
10										
11										
12							28			
13										
14										
15										
16										
17										
18										

TABLE IV.—*Rye in Sodium Carbonate.*

Table showing number of seeds germinated each day in the diff percents.

Number of days from beginning of test.	Water.	0.1 percent.	0 4 percent.	0.7 percent.	1 percent.	2 percent.	3 percent.	4 percent.	5 percent.	7 percent.
1	24	28	13	21	21					
2	46	46	38	38	26	6	2	1		
3	47		41	40		7	7	2		
4			42			9	9			
5			43	41						
6							11			
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										

TABLE V.—*Rye in Sodium Chloride.*

wing number of seeds germinated each day in the different percents.

0.1 percent.	0.4 percent.	0.7 percent.	1 percent.	2 percent.	3 percent.	4 percent.	5 percent.	7 percent.	9 percent.
23	14	8	3	1					
46	41	40	32	17	1				
48	48	42	43	27	6				
		44		30	14	4			
		46		31	16	7	4		
				33	18		5		
						8	6		
						9			
					19				
									1

TABLE VI.—*Wheat in Sugar.*

wing number of seeds germinated each day in the different percents.

0.1 percent.	0.4 percent.	0.7 percent.	1 percent.	2 percent.	3 percent.	4 percent.	5 percent.	7 percent.	9 percent.
1								1	1
19	17	15	12	15	16	16	14	7	6
28	29	30	31	20	25	30	24	22	14
32	30	32	35	24	30	36	31	29	21
34	33	34	37	29	41	40	32	32	25
38	36	39		34	44		33	34	26
39	37	44				41	35	36	27
41								37	
42		45			45	42	36		32
	38		38					38	
43	39		39	35			37	39	
	40					43			
				36	47			40	34
		47	40	37					
				38			38		35
44									
							39		

TABLE VII.—*Wheat in Magnesium Sulphate.*

Table showing number of seeds germinated each day in the dif percents.

Number of days from beginning of test.	Water.	0.1 percent.	0.4 percent.	0.7 percent.	1 percent.	2 percent.	3 percent.	4 percent.	5 percent.	7 percent.
1	1									
2	15	12	11	15	11	7	4			
3	24	25	30	31	29	17	20	11	3	1
4	29	29	35	34	31	32	30	25	16	9
5	32	31	42	35	34	36	39	30	20	24
6	34	35	45	36		38	41	31	21	25
7	37	36		39	37	39				
8				40						26
9	39			42				33		
10	40	40		43	39					
11		41		44	41					27
12	41	42	46							28
13	42							36		
14	43	43	47				42			
15	44			45	43			38		
16			48	46	44		43		22	29
17				47						
18		44	50							

TABLE VIII.—*Wheat in Sodium Sulphate.*

Table showing number of seeds germinated each day in the di percents.

Number of days from beginning of test.	Water.	0.1 percent.	0.4 percent.	0.7 percent.	1 percent.	2 percent.	3 percent.	4 percent.	5 percent.	7 percent.
1	1	2								
2	15	12	13	6	3	2				
3	24	19	33	23	23	12	9	7		
4	29	24	35	30	32	20	19	14	4	
5	32	30	36	33	36	23	28	18	16	6
6	34	32	39	34	37	24	30	22	21	
7	37	33		36		25		23	23	
8				38						
9	39	35		39	38	27	32	25		
10	40	36	40			28		26		
11		40	42	40						
12	41								24	
13	42		44	42				28	28	
14	43			45		32	33			
15	44						34	31	29	
16		42				33	35		31	
17								32		
18		43						33		

TABLE IX.—*Wheat in Sodium Carbonate.*

showing number of seeds germinated each day in the different percents.

Water.	0.1 percent.	0.4 percent.	0 7 percent.	1 percent.	2 percent.	3 percent.	4 percent.	5 percent.	7 percent.	9 percent.
1										
15	24	3	3							
24	37	21	21	6	1					
29	41	30	28	8	7	5				
32	42	37	31	18	12	6				
34	43	38	32	21		7	2			
37			35	22	14					
		40								
39										
40	45									
	46	43			15					
41										
42		44	37							
43										
44	47	45	38							
	49		39							
	50									

TABLE X.—*Wheat in Sodium Chloride.*

showing number of seeds germinated each day in the different percents.

Water.	0.1 percent.	0.4 percent.	0.7 percent.	1 percent.	2 percent.	3 percent.	4 percent.	5 percent.	7 percent.	9 percent.
1										
15	12	7	5							
24	19	25	20	9	5					
29	28	31	32	22	19	2				
32	33	35	33	30	29	4	1			
34	34	37	34	34	33	6	5			
37	38			35						
		38	35							
39		39	37			10				
40		40	38	36		11				
	39				34	12				
41					35					
42										
43	41			37						
44	42									
						14				
							7			
					39	16				

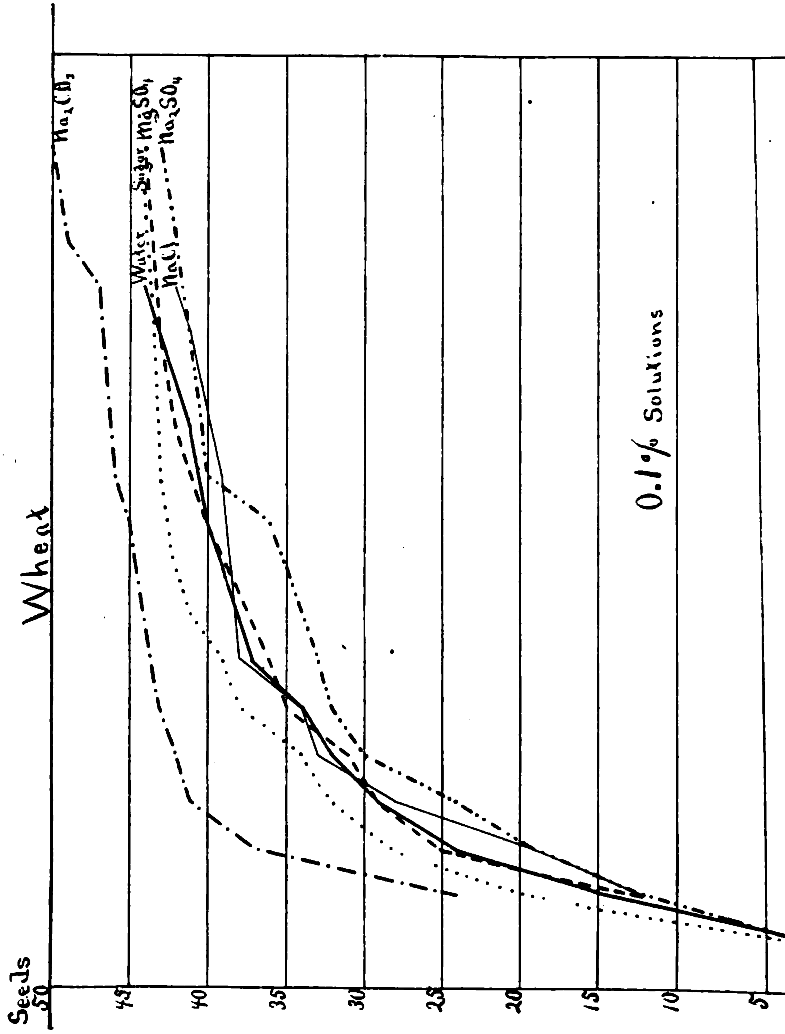

Wheat
Seeds
50
45
40
35
30
25
20
15
10
5
Na_2CO_3
Water
Sugar
$MgSO_4$
$NaCl$
Na_2SO_4
0.1% Solutions

CHART I.

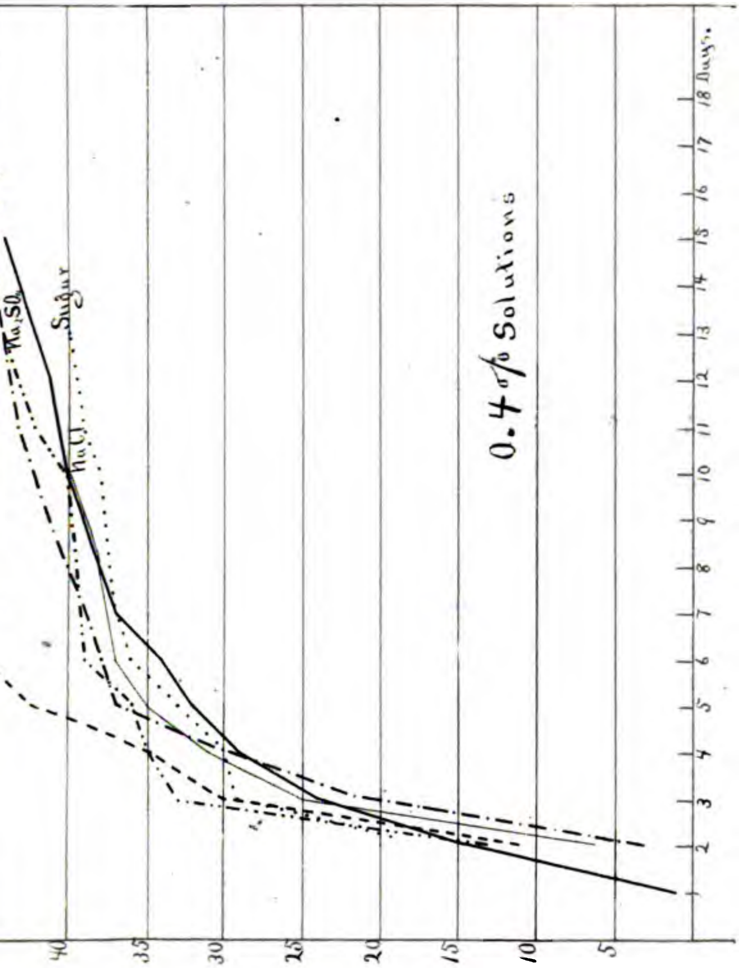

0.4% Solutions
Sugar
NaCl
Na₂SO₄
40
35
30
25
20
15
10
5
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18 Days.

CHART II.

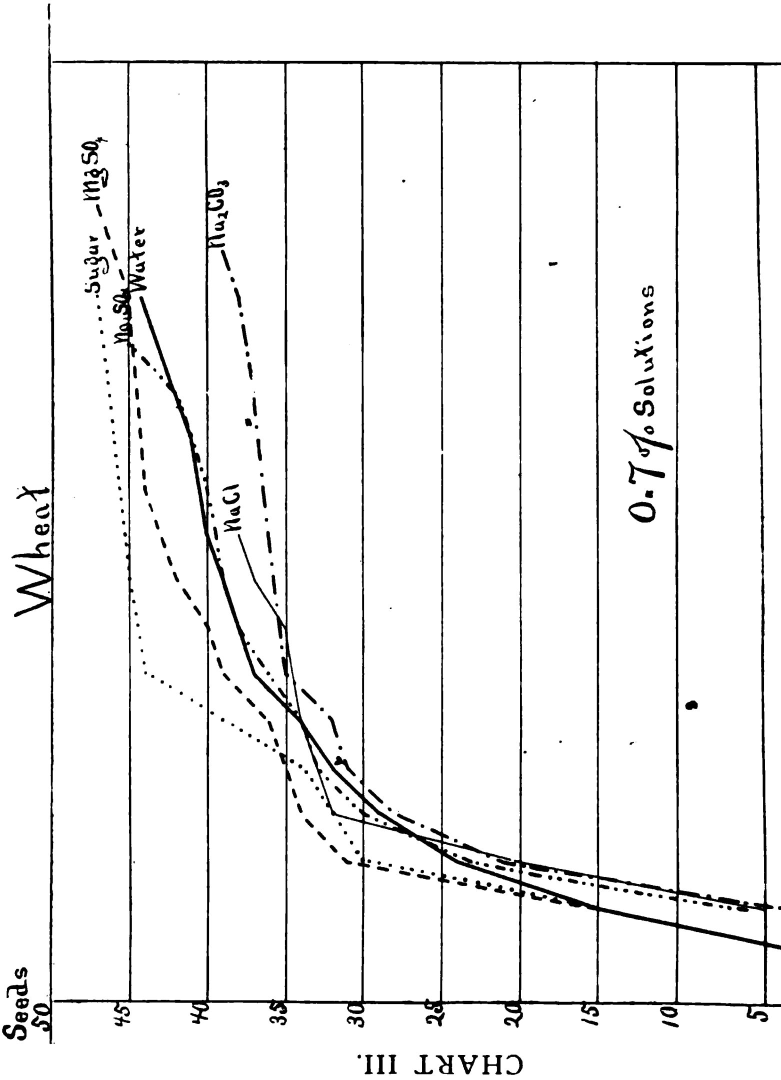

Wheat
0.7% Solutions
Sugar
MgSO4
Na2SO4
Water
Na2CO3
NaCl
Seeds
50
45
40
35
30
25
20
15
10
5

CHART III.

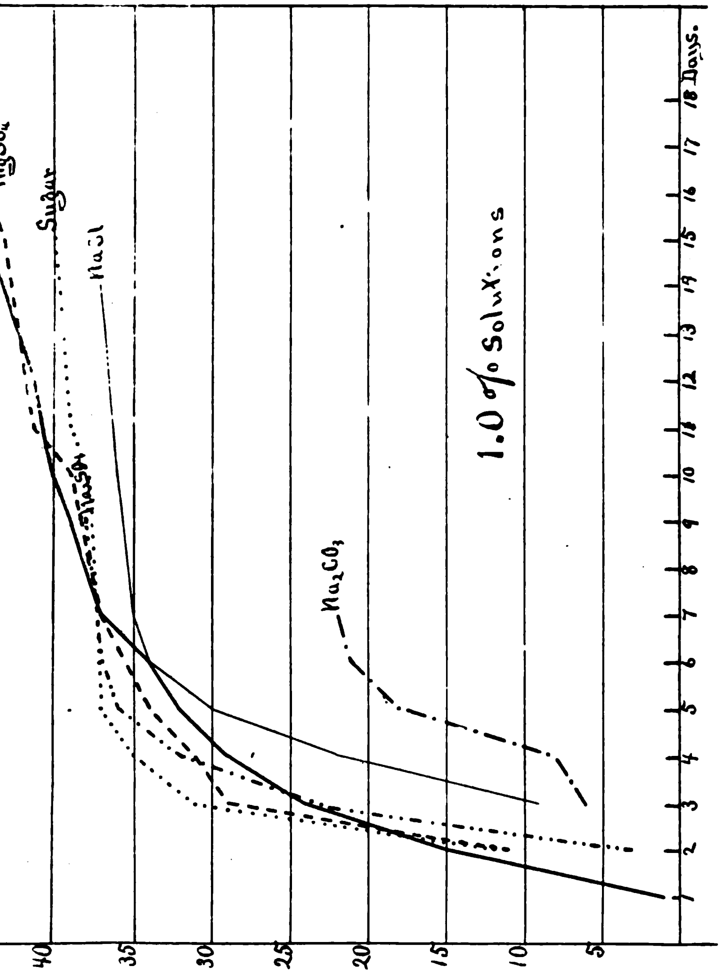

1.0 % Solutions
MgSO$_4$
Sugar
NaCl
Na$_2$SO$_4$
Na$_2$CO$_3$
40
35
30
25
20
15
10
5
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18 Days.

CHART IV.

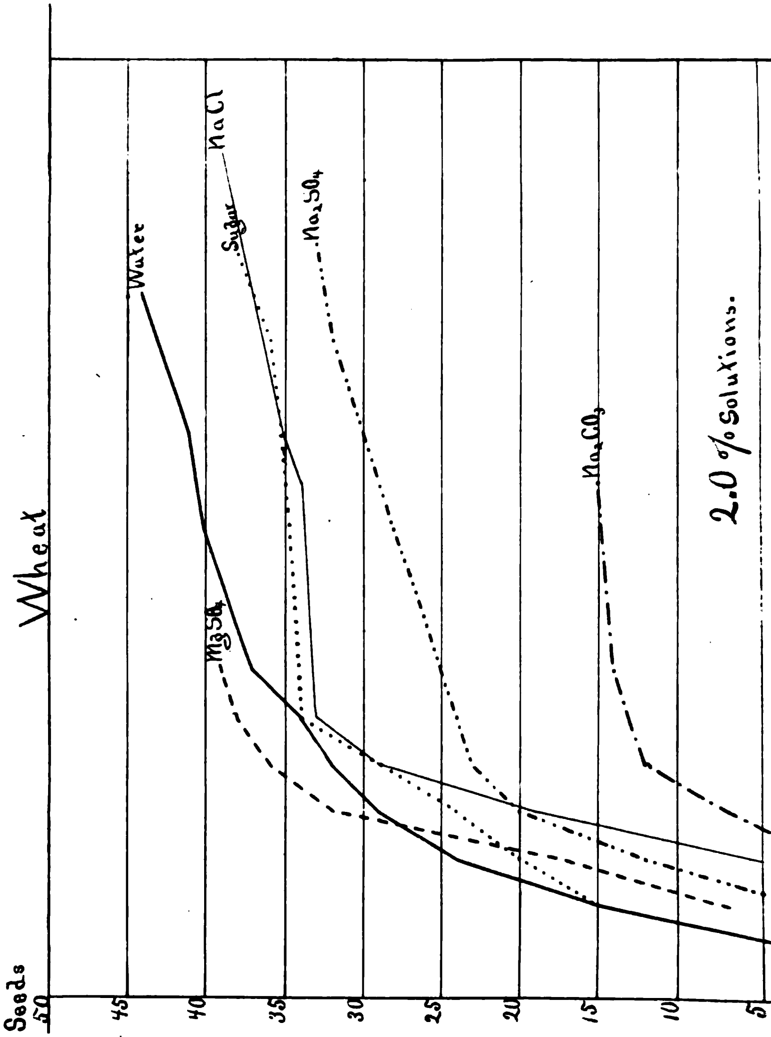

Wheat
Water
NaCl
Sugar
Na₂SO₄
MgSO₄
Na₂CO₃
2.0 % Solutions.
Seeds
50
45
40
35
30
25
20
15
10
5

CHART V.

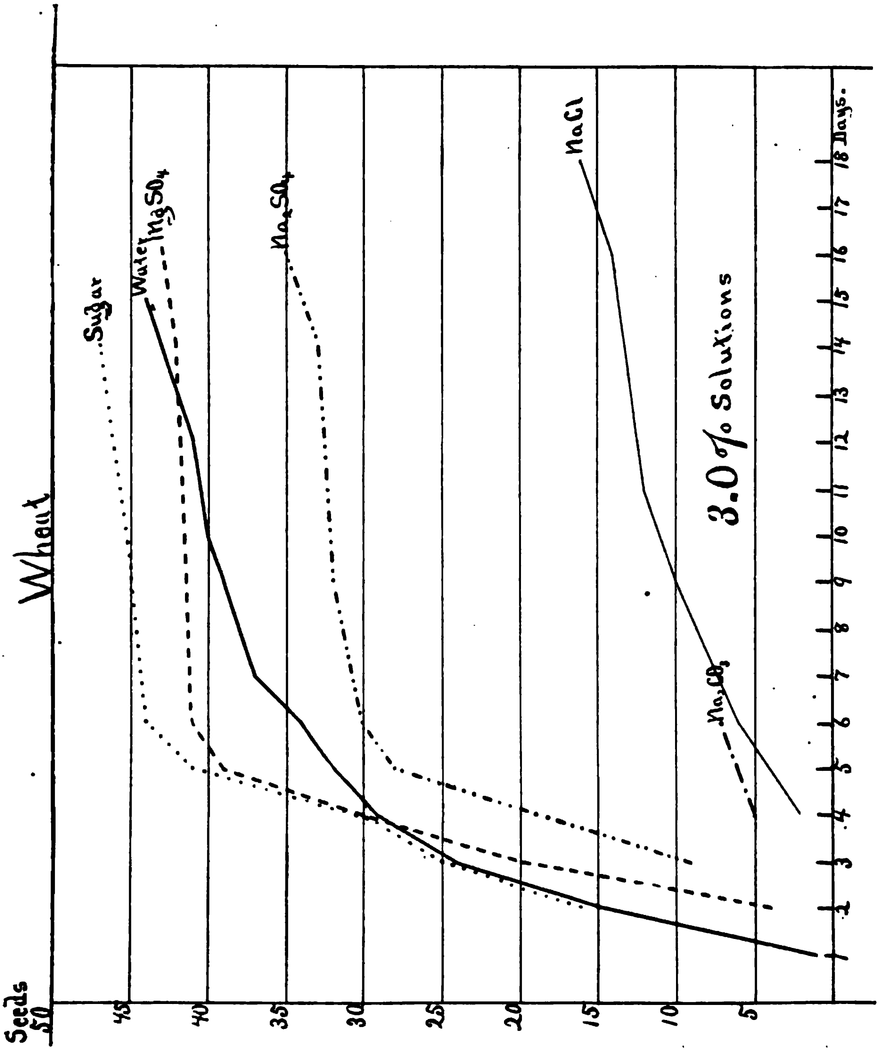

Wheat
3.0% Solutions
Sugar
Water
MgSO₄
Na₂SO₄
NaCl
Na₂CO₃
Seeds 50
45
40
35
30
25
20
15
10
5
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18 Days.

CHART VI.

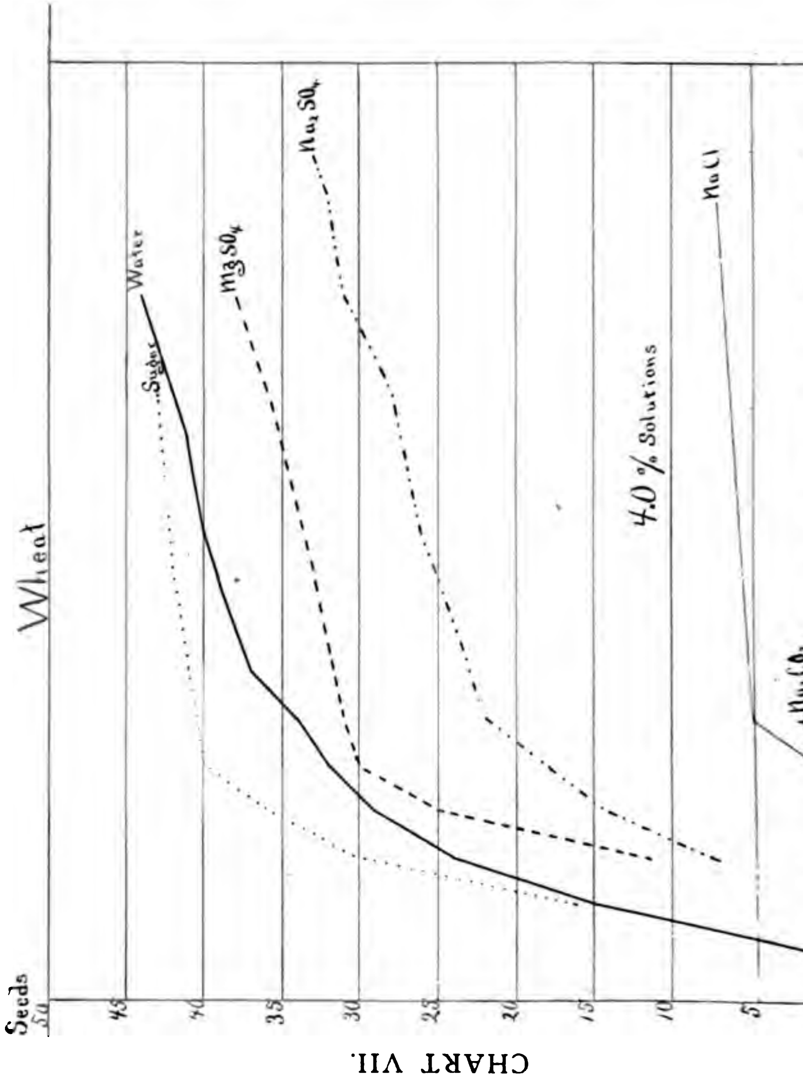

Wheat
4.0 % Solutions
Water
Sugar
$MgSO_4$
Na_2SO_4
NaCl
Seeds
50
45
40
35
30
25
20
15
10
5

CHART VII.

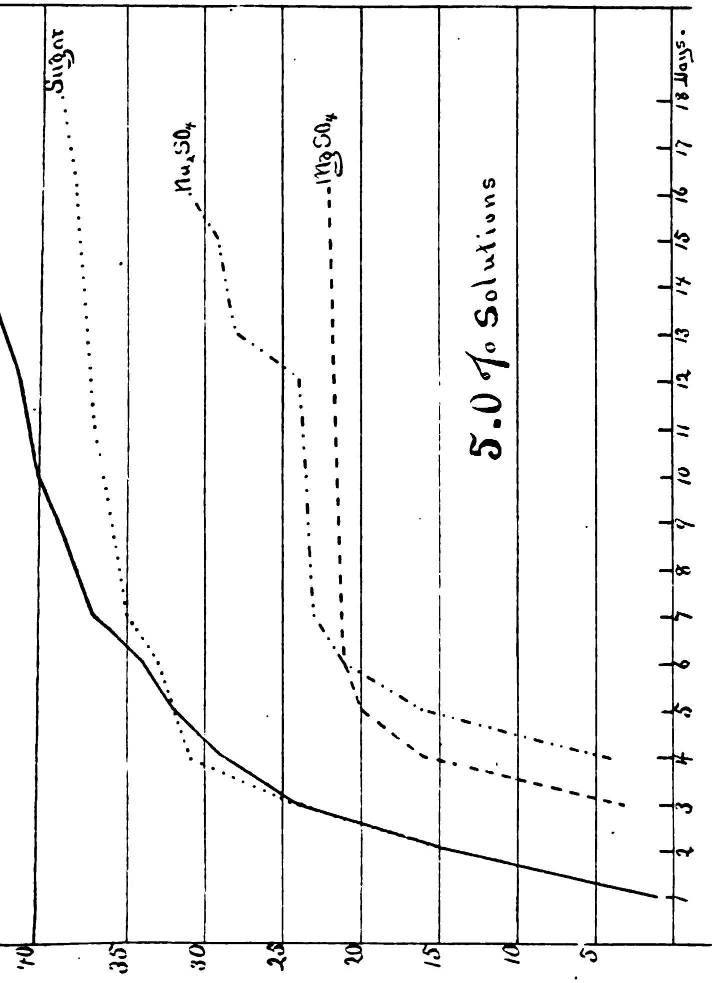

5.0 % Solutions
Sugar
Na_2SO_4
$MgSO_4$
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18 Days.
5
10
15
20
25
30
35
40

CHART VIII.

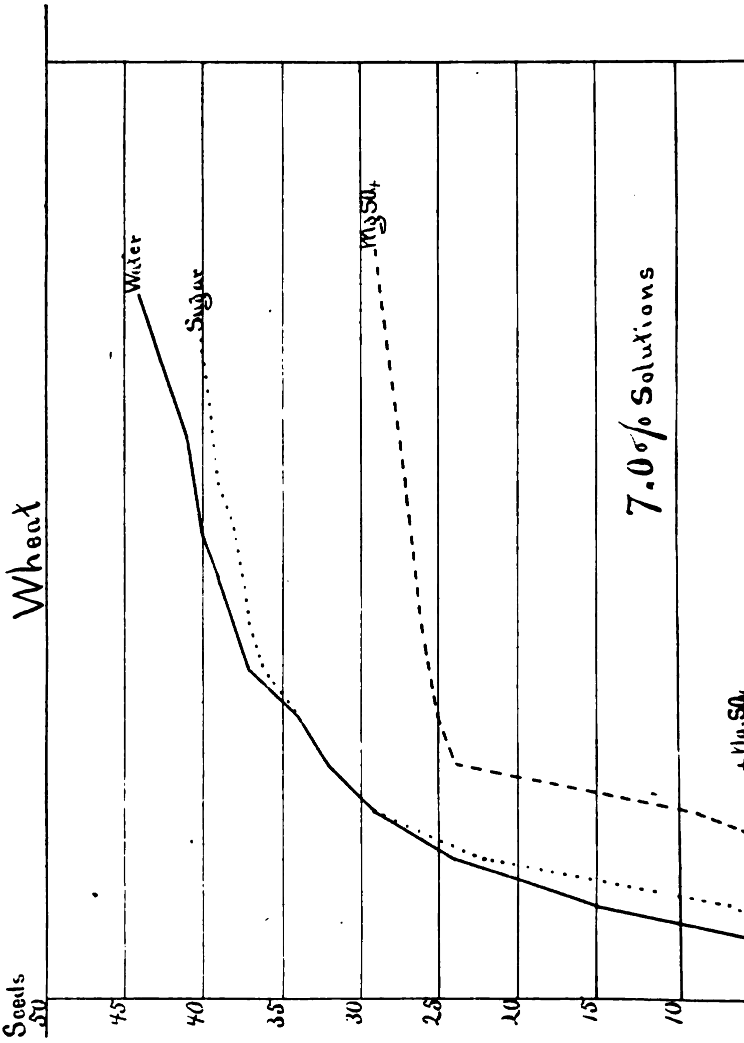

Wheat
7.0% Solutions
Water
Sugar
$MgSO_4$
Seeds
50
45
40
35
30
25
20
15
10

CHART IX.

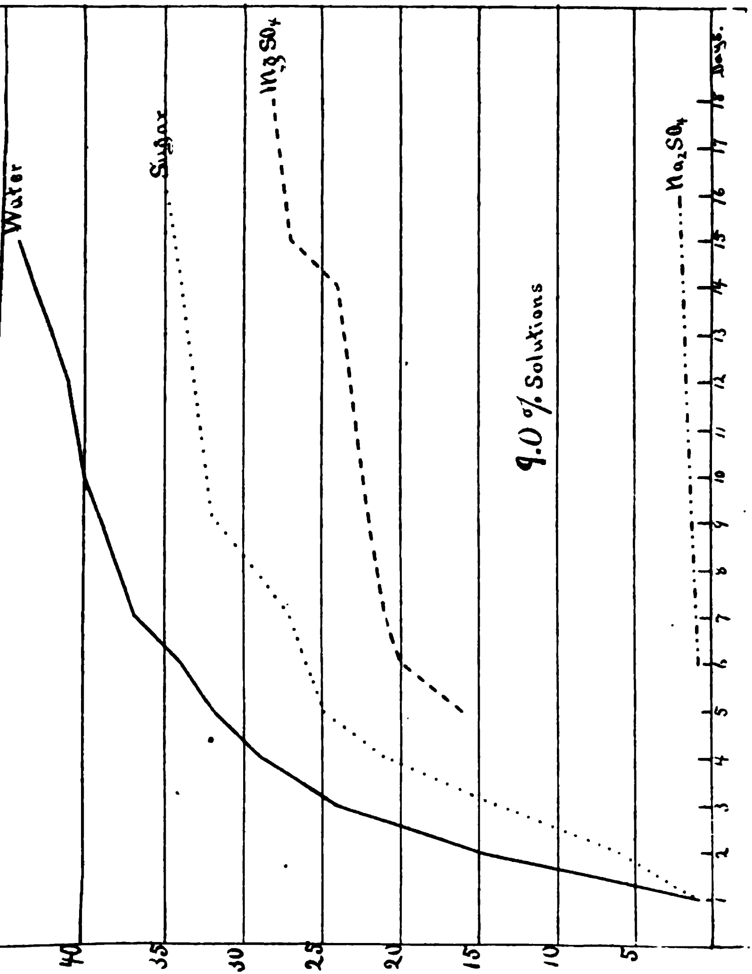

Water
Sugar
MgSO4
Na2SO4
9.0 % Solutions
Days.
40
35
30
25
20
15
10
5
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

CHART X.

DESCRIPTION AND RESULTS OF A CHECK TO TEST T CONCLUSIONS DRAWN FROM THE GERMINATING EXPERIMENTS.

The germinating device used in the foregoing exp ments, that is, the method of germinating the seeds betw cloths raised slightly above the surface of the solution with all their edges dipping, is subject to the possible er that, due to the selective absorbtion of the cloth, the s tion surrounding the seed may not be the same as the b of the solution. This chance for error was anticipated once each day, and sometimes more often, the cloths co ing the seeds were removed and plunged into their res tive solutions. This in all probability practically overc the influence of the selection which took place during time the moisture was supplied by capillarity. But to termine the real validity of the results obtained a check was carried out with the different percents of one of salts, sodium sulphate, in which the factor just mentic is eliminated and the seeds were germinated in sand ins of between clothes.

DESCRIPTION OF EXPERIMENT.

Some clean, sharp river sand was obtained and a s cient quantity was screened through a 1 mm. sieve. Th ganic matter was removed by allowing 20 liters of 10 cent hydrochloric acid to leach through it, the sand b first placed in an earthenware vessel with an openin the bottom. It was then washed for several hours with ning water, and finally with distilled water till the chlo disappeared in the leachings. (The chlorides were no tirely eliminated, as silver nitrates showed the merest t remaining.) The sand was then dried by heating it for s time in shallow pans to the temperature of boiling or tle above.

anite-ware plates were used in the test to hold the
ontaining the different percents of alkali, 1200 gm.
l being placed in each. This filled them almost even
ne sand being about seven-eighths of an inch deep.
er half of this sand was removed and fifty carefully
d seeds of Chili wheat and fifty seeds of Spring rye
laced close together, though not touching on this low-
er of sand. They were then pressed down, with a
surface, till their upper edges were even with the
f the sand. It was the original intention to use a flat
screen to lay over the seeds at this point, covering it
ne remaining sand. The seeds would in this way be
nded by sand and by merely lifting the screen they
eadily be examined. A piece of cloth was, however,
uted in place of the metal screen on account of the
lity of the metal rusting or being corroded by the salt
us adding another factor which might influence the
ation. So a piece of fine cheese-cloth with a large
as placed over them and the upper layer of sand was
ly poured on. A pane of window glass of suitable
s then placed over each plate to prevent evaporation
he solutions were added. Previous to this a stock so-
of 10 percent sodium sulphate had been carefully
p, the salt being heated to a low red heat for a short
hen cooled and weighed.

was found that 20 percent of moisture added to the
rought it somewhat near the point of saturation, or
y desirable condition for the process of germination,
ach plate containing 1200 gm. of sand there was
300 cc. of solution, this 300 cc. of solution being 20
of the sand and water taken together.

the simple process of germination, the seed is af-
nly by the salts or substances dissolved in the solu-
rounding it. The insoluble material in the soil has
ical duties, only, to perform. That plants absorb

only those substances that are in solution seems so axi atic that it is scarcely necessary to quote authorities the point, but Johnson in "How Crops Grow," page says, "The food of the plant, so far as it is derived from soil, enters it in a state of solution, and is absorbed with water which is taken up by the rootlets." We have, in experiment of this kind, therefore, to do with the amoun soluble material with its relation to the amount of w present and *not* with its relation to the amount of This point has apparently been ignored in alkali invest tions in general. In the soil analyses the percent of al is given but no apparent attention is paid to the amoun moisture in the soil. To arrive at trustworthy conclus it is highly important that the moisture content be ta into careful consideration, for in the arid regions, where alkali question becomes a problem, the moisture con varies greatly. The relation of the soil to the amount of it may contain is the same no matter how the mois varies, while it is the variation of the latter which aff the seed or plant. If, for instance, the amount of mois in the soil changes from 20 percent to 10 percent, the cent of salt in the soil water is doubled, providing the p of saturation is not passed. In that case a part of the crystalizes out and becomes as inert as the other insol material in the soil. The importance, then, of dealing the amount of soluble salts in its relation to the amou soil-water, and not to the total amount of dry soil, is c apparent.

The 300 cc. of solution, therefore, which was to be a to each 1200 gm. of sand was brought to the requ strength by adding enough of the 10 percent stock solu already mentioned, to make it similar to the various tions used in the previous test where the seeds were ger ated between cloths. The strengths of the solutions use as follows: 9 percent,7 percent,5 percent,4 percent,3 per t, 1 percent, 0.7 percent, 0.4 percent, 0.1 percent. The two plates was wet with distilled water, this making e check. The seeds being placed in dry sand, no would occur till moisture was added. The solutions lded to all the plates within about an hour. The of each plate was then carefully taken. For the first s the plates were weighed, but after allowing for the of the seeds which had germinated and been re- the evaporation was found to be very slight. It was d day before sufficient loss of weight could be de- o warrant adding water to bring back to the initial At intervals later on water was added when neces- bring the weights of the plates back to their original . The first examination of the seeds occurred 16 fter the solutions were added; all later examinations l about 24 hours apart.

results of the tests are given in the following ta-

TABLE XI.—*Rye.*

umber of seeds germinated in the different solutions.

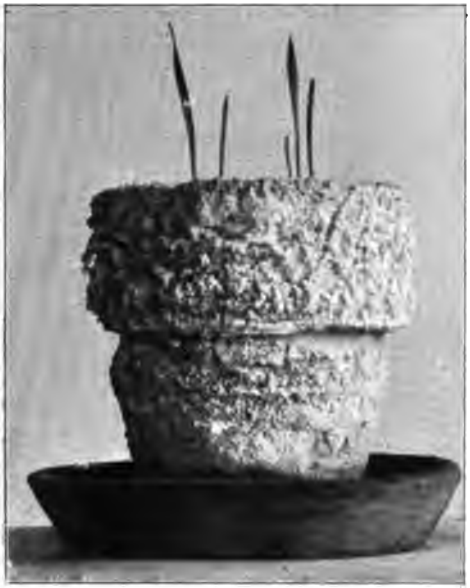
Water.	Water (average).	0.1 percent.	0.4 percent.	0.7 percent.	1.0 percent.	2.0 percent.	3.0 percent.	4.0 percent.	5.0 percent.	7.0 percent.	9.0 percent.
	(1)			1							
47	(45)	44	46	42	43	38	34	20	16		
49	(49)	47	47	49	45	43	44	36	32	1	
					47	44		41	38	8	
						45			40	15	6
								42	41	17	13
					48		45	43			15
										18	18
			48					44		20	23
											25

TABLE XII.—*Wheat.*

Number of seeds germinated in the different solutions.

Number of days from beginning of test.	Water.	Water.	Water (average).	0.1 percent.	0.4 percent.	0.7 percent.	1.0 percent.	2.0 percent.	3.0 percent.	4.0 percent.	5.0 percent.	7.0 percent.
1												
2	11	13	(12)	19	8	6	7		1			
3	46	44	(45)	48	46	45	46	36	25	2		
4	47	46	(47)		48	46	47	44	35	20	6	
5	48					48		47	43	29	23	2
6					49				44	40	31	11
7									45		33	14
8									46	41	36	21
9										42	39	30
10	49	47	(48)									
11												31
12												
13												
14		48										3
15												
16												
17												
18												

Comparing the table giving the results with whe
the table reporting the original test with wheat, fou
the first part of this report, where the seeds were ge
ated between cloths, it will be seen that the seeds plant
sand germinated much more readily and also that a
part of them germinated than when planted between c
That seeds in general act very differently with dif
germinating devices has been remarked by the lat
Hicks of the Department of Agriculture at Washingt
C., who had wide experience in germinating tests. He
for instance, that it is with great difficulty that some
are germinated between blotters while they germinat
ily between cloths whose edges are allowed to dip in
He says there is no apparent explanation for many of
variations. This general fact doubtless explains why
germinated so much more readily when placed in san
when placed between cloths. With the rye this is n
case, but if anything the reverse, for it will be noted t



Pot containing 9 percent of Sodium Sulphate, showing incrustation on surface. About one-half natural size.

General view of bench, showing arrangement of pots.

iginal experiment, when they were planted between , there were quite a number germinated the first day, case as many as 60 percent, while where they were d in sand scarcely any were germinated, 4 percent the most in any particular case. This variation one r the other does not affect the general conclusions ay be drawn, as the results in the respective tests are rable with each other. So taking each test separately mparing the number germinated and the rate of ger- ion in the different percents of the salts to the rate, f the germination in the water, we can determine the e effect of a certain percent of the salt on the germin- of the seed.

is therefore quite apparent that a careful comparison tables shows that notwithstanding the variation as number germinated and the decided difference in the germination, the percent at which the salt exercises ding effect is the same in both experiments.

RIMENT IN GROWING PLANTS IN POTS IN THE PRESENCE OF ALKALI SALTS.

is probable that definite conclusions cannot be from this experiment in regard to the effect of a given t of salt on the growth of plants. As the evaporation great from the soil surface and from the surface of rous pots as well, the strength of the salt solution in varied considerably. The effect of this evaporation e way the salt was carried to the surface of the pots e containing large amounts of alkali is well shown in stration of a pot covered with incrustations of salt. er was added each day to supply the amount lost by ation, this salt was scraped off and washed back into and it is believed the general results in showing the ion of growth by large amounts of salts are of suf- alue to be published, and the effects produced by the

same percents of different solutions are comparable. A
would be expected there are wide variations and irregula
ties in the tables between one strength of solution and tl
next, but as a whole the experiment shows what may be e
pected of the different salts and of the quantity present
the soil.

A general view of the pots at the time the seeds we
planted is given in the illustration. The plates on the benc
back of the pots are as they were used in the first germin
tion experiment which was afterward abandoned and r
peated in the manner already outlined.

One hundred and fifty-three two and one-half inc
pots were used. Clean river sand was screened through
one millimeter sieve and then put in pans which were place
over the furnaces in the assay department for a few hour
One hundred eighty grams of this sand were put in each p
and these were placed in saucers on the center bench of tl
greenhouse on moist sand. Each pot had its number place
on it with asphalt varnish. To each pot was added 60 cc.
solution. This contained the required amount of salt an
also enough of the salts of the normal nutritive solutio
commonly used in water cultures, to make the solution
equal in nutritive value irrespective of the other salts. Tl
normal nutritive solution used is the one given for wat
cultures in "Frank Lehrbuch der Botanik:"

1.0 g.	$Ca(NO_3)_2$
.25 g.	KCl
.25 g.	$MgSO_4$
.25 g.	KH_2PO_4
1.75 g. in 1000 cc.	H_2O

This was made in more concentrated form and enou
added, in making up the 60 cc. of solution each pot was
receive, to make the percent of the nutritive solution t
same as in the formula given. This, of course, increased t
total percent of salts in the solution 0.175 percent, which

ite a factor in the solutions containing the lower percents the salts, but in the solutions containing more than one rcent of salt this additional amount would not change the ults materially. Sixty cc. of solution added to 180 g. of d would make the percent of moisture in the total ount twenty-five. To every three pots was added the ne solution; for example, the first three contained merely ter, the second three 0.1 percent sodium chloride, the rd three 0.1 pecent sodium sulphate, etc. Five seeds of eat were planted in the first pot, five of clover in the next, l five of rye in the next. The pots containing wheat were h placed on the balances and small pieces of stone or ken crockery were placed with them to make each weigh g. The pots and weights were then returned to their re- ctive saucers. Every other day at the beginning, and ry day in the latter part of the test, these pots were ighed and enough water added to bring them back to ir original weight. This amount was measured and re- ded and a like amount was added to the clover and rye s containing identical solutions. After it became evi- t that the clover seeds would not germinate, the pots in ich they were planted were cast out. When the wheat l rye were nicely up the strongest plant in each pot was cted and the others were destroyed, leaving but one nt in each pot.

The test was continued for ninety days, but on the ac- nt of the pots being so small it was impossible to keep sand moist enough, by adding water once a day, to pre- t the plants from suffering from lack of it after they had ined a height of ten or more inches. This fact would no bt vitiate the results, as we have reason to suppose the poration from the soil containing a large percent of al- i is less than from soil freer from the salts, for if the nts suffered from lack of moisture, those in large ounts of alkali would probably suffer less from this

cause, in consequence of which the results would not
comparable. The results have been tabulated for the fi
forty days of the test. From the average amount of wat
added each day during this time to bring the percent
moisture up to twenty-five, it will be seen that the plants
all probability did not suffer for water at any time. On t
sides of the pots containing the larger percents of the sal
particularly with sodium sulphate and magnesium sulpha
a white incrustation was formed. This did not accumul
to any extent on the surface of the sand as it was dissolv
here when water was added. The incrustation on the o
side was scraped into a saucer and from it returned to t
pot, where it was soon redissolved. On account of the va
ation in the concentration of the solutions in the po
caused by this incrustation, only general conclusions can
drawn from the experiment. The seeds were planted F
ruary 7, and in the following tables are given the heights
the plants 16 days later, February 23, and also 40 days la
March 19. The daily average amount of water added,
given in the tables, is the average up to and includ
March 15. The amount added to the rye is of no particu
value as it is the same as that added to the wheat.

From the tables it will be seen that the daily average
water is less in those pots containing the larger percent
salts. The evaporation from a solution containing sal
less than from pure water. It is to be inferred that
reason the pots containing higher percents received
water, was due to this fact and that the evaporation is
duced in soils containing large amounts of alkali.
fact that the plants were not so large in the hig
percents, indicates that they absorbed less water,
that the greater loss of moisture from the pots
taining lower percents is not due entirely to evap
tion from the soil and pot. That the evaporation f
soil containing large percents of alkali is less than f

ntaining little salt is a matter of common observa-
id is substantiated by the fact that the evaporation
he pots containing large percents of alkali was less
thers during the early part of the test before the
were up. This point is not brought out in the tables,
average amounts of water for the time are given. On
ts containing the larger percents of sugar a black
formed not only on the surface of the sand but also
pot. This doubtless affected the evaporation to a
l degree. From the last two tables given it will be
iat a large percent of sodium carbonate has the great-
rimental effect on the growth of the plants, sodium
e ranks next, and magnesium sulphate and sodium
te have about the same effect. The evaporation in
oles is indicated by the average amount of water
iry to add each day to bring the pots back to their
l weight.

TABLE XIII.—*Sodium Chloride.*

Wheat.				*Rye.*			
Strength of solution.	Evaporation.	Height in 16 days.	Height in 40 days.	Number of pot.	Strength of solution	Height in 16 days.	Height in 40 days.
rcent	*c. c.*	*inches*	*inches*		*percent*	*inches*	*inches*
0.0 Vater)	23	3.5	5.3	3	0.0 (Water)	4.5	7.2
0.1	15	3.5	7.5	6	0.1	3.2	5.1
0.4	15	3.3	6.0	21	0.4	4.3	9.3
0.7	15	3.5	4.3	36	0.7	4.5	6.0
1.0	14	4.3	7.4	51	1.0	3.8	4.2
2 0	13	3.5	8.7	66	2 0	3 6	6.0
3 0	12	2.7	5.3	81	3.0	4.3	5.9
4.0	12	1.7	6.4	96	4.0*		
5.0	10	not up	4.1	111	5.0	1.3	2.1
7.0	11	"	3.4	126	7.0*		
9.0	*			141	9.0*		

r came up.

TABLE XIV.—*Sodium Sulphate.*

Wheat.					*Rye.*		
Number of pot.	Strength of solution. •	Evaporation.	Height in 16 days.	Height in 40 days.	Number of pot.	Strength of solution.	Height in 16 days.
	percent	*c. c.*	*inches*	*inches*		*percent*	*inches*
1	0.0 (Water)	23	3.5	5.3	3	0.0 (Water)	4.5
7	0.1	17	3.6	7.0	9	0.1	4.4
22	0.4	16	4.4	9.6	24	0.4	5.0
37	0 7	14	4.1	9.1	39	0.7	2.5
52	•1.0	18	3.4	7.4	54	1.0	3.8
67	2.0	16	5.5	10.4	60	2.0	4.4
82	3.0	14	3.3	8.2	84	3.0	3.9
97	4.0	10	3.9	9.2	99	4.0	4.0
112	5.0	12	2.7	8.5	114	5.0	3.5
127	7.0	12	0.2	2.5	129	7.0	3.3
142	9.0	12	1.1	3.4	144	9.0	2.9

• Plant partly dead.

TABLE XV.—*Sodium Carbonate.*

Wheat.					*Rye.*		
Number of pot.	Strength of solution.	Evaporation.	Height in 16 days.	Height in 40 days.	Number of pot.	Strength of solution.	Height in 16 days.
	percent	*c. c.*	*inches*	*inches*		*percent*	*inches*
1	0.0 (Water)	23	3.5	5.3	3	0.0 (Water)	4.5
10	0.1	17	4.4	8.3	12	0.1	4.1
25	0.4	16	4.2	7.7	27	0.4	4.0
40	0.7	16	4.1	9.1	42	0.7	4.2
55	1.0	14	2.5	4.5	57	1.0	3 9
70	2.0	15	2.3	dead	72	2.0	3.1
85	3.0	14	1.2	"	87	3.0	2.6
100	4.0*				102	4.0	2.2
115	5.0	13	1.2	"	117	5.0	1.1
130	7.0	12	not up	dead†	132	7.0	.5
145	9.0*				147	9.0‡	

* Plants were destroyed by mice on the eleventh day.
† Died in two or three days after coming up.
‡ Never came up.

TABLE XVI.—*Magnesium Sulphate.*

Wheat.				*Rye.*			
trength of solution.	Evaporation.	Height in 16 days.	Height in 40 days.	Number of pot.	Strength of solution.	Height in 16 days.	Height in 40 days.
cent	*c. c.*	*inches*	*inches*		*percent*	*inches*	*inches*
.0 ter)	23	3.5	5.3	3	0.0 (Water)	4.5	7.2
.1	16	3.5	6.4	15	0.1	4.2	6.7
.4	14	4.2	9.4	30	0.4	4.6	6.5
.7	12	4.0	12.2	45	0.7	3.9	6.5
.0	14	3.7	8.1	60	1.0	4.5	7.8
.0	11	3.2	8.8	75	2.0	4.1	6.0
.0	11	4.6	9.6	90	3.0	5.2	9.2
.0	12	4.0	5.2	105	4.0	4.1	5.8
.0	10	3.5	5.4	120	5.0	4.4	5.6
.0	10	3.5	4.5	135	7.0	4.2	3.5*
.0	9	1.0	3.3	150	9.0	4.0	4.5

lead.

TABLE XVII.—*Sugar.*

W*heat.*				*Rye.*			
trength of solution.	Evaporation.	Height in 16 days.	Height in 40 days.	Number of pot.	Strength of solution.	Height in 16 days.	Height in 40 days.
cent	*c. c*	*inches*	*inches*		*percent*	*inches*	*inches*
.0 ter)	23	3.5	5.3	3	0.0 (Water)	4.5	7.2
.1	13	4.6	10.0	18	0.1	3.7	5.5
.4	17	4.3	9.1	33	0.4	3.0	5.5
.7	15	3.6	8.3	48	0.7	4.1	7.5
.0	15	3.4	5.5	63	1.0	4.6	7.6
.0	14	3.4	7.5	78	2.0	4.2	6.0
.0	12	3.4	5.0	93	3.0	3.3	4.0
.0	13	3.4	6.2	108	4.0	3.0	3.8
.0	13	3.3	4.8	123	5.0	4.0	5.0
.0	10	3.0	3.5	138	7.0	4.7	4.8
.0	10	2.9	4.1	153	9.0	3.4	3.2*

artly dead.

TABLE I—*Imbibition of Water from One Per Cent Salt Solutions.*

No.	Kind of Seed	Solution of	Osmotic Pressures, Atmospheres	PERCENTAGE OF WATER ABSORBED.														
				12 hours	24 hours	36 hours	48 hours	60 hours	72 hours	84 hours	96 hours	108 hours	120 hours	132 hours	144 hours	156 hours	168 hours	180 hours
1	Wheat	Pure water	0	30.3	46.4	50.2	54.6	57.6	60.8	63.4	64.6	66.0	68.2	68.0	69.4	70.4	70.2	70.2
2	Wheat	Sugar	.7	31.6	45.4	52.4	57.0	60.4	63.0	65.6	66.8	68.4	71.2	71.5	73.3	73.8	73.6	74.0
3	Wheat	Sodium Sulphate . .	3.9	28.4	41.4	46.2	49.6	51.8	53.8	55.0	55.8	56.4	58.8	58.6	56.9	60.2	60.6	60.8
4	Wheat	Sodium Chloride . .	7.4	26.5	39.8	44.2	47.2	40.8	51.8	53.2	53.2	53.2	54.2	[illegible]	54 0	54.0	54.0	54.4
5	Wheat	Sodium Carbonate .	4.3	29.1	43.1	47.5	50.5	53.9	55.4	57.6	57.6	58.6	61 0	61.4	63.0	63.0	63.2	63.4
6	Wheat	Magnesium Sulphate	2.8	28.7	42.5	48.1	50.5	54.1	56.1	58.5	59.5	59.5	61.2	62.4	64.0	64.3	64.3	64.3
7	Rye	Pure Water	0	31.7	52.1	59.7	66.3	73.3	78.7	82.5	85.6	88.8	92.2	93.8	94.6	95.2	94.6	95.0
8	Rye	Sugar	.7	32.7	51.9	60.3	67.3	73.9	79.1	83.0	88.4	91.5	94.8	96.8	99.8	100.5	100.7	100.9
9	Rye	Sodium Sulphate . .	3.9	31.2	47.2	55.2	60.0	65.4	69.8	72.8	74.4	76.8	79.0	79.8	80.4	80.8	81.0	81.2
10	Rye	Sodium Chloride . .	7.4	30.0	46.2	53.8	59.6	65.2	69.0	71.8	74.0	74.8	76.6	79.6	80.0	80.2	80.8	81.2
11	Rye	Sodium Carbonate .	4.3	30.2	46.5	54.7	60.7	65.5	69.1	71.3	71.9	73.1	74.9	75.7	75.7	76.7	77.1	77.5
12	Rye	Magnesium Sulphate	2.8	29.5	45.8	54.4	60.0	63.6	68.1	70.9	73.5	72.7	73.3	76.3	78.3	78.3	78.3	78.7
13	Clover	Pure Water.	0	1.9	5.5	5.5												
14	Clover	Sugar	.7	1.4	3.7	3.7												
15	Clover	Sodium Sulphate . .	3.9	3.9	4.4	3.9												
16	Clover	Sodium Chloride . .	7.4	.9	2.5	.9												
17	Clover	Sodium Carbonate .	4.3	3.4	2.4	1.4												
18	Clover	Magnesium Sulphate	2.8	.0	1.4	1.9												

riments, doubtless on account of its caustic effect. ye all the salts retard imbibition, but not in pro- ion to their osmotic pressure. Apparently rye is less ted by differences in alkali than wheat and this is con- ed by the germination tests. It will be noticed that water is imbibed by rye than wheat.

IMBIBITION OF WATER BY WHEAT.

In the next experiment wheat was chosen as the seed d and isomotic solutions of the common alkalies were up together with a sugar solution of the same osmotic gth for comparison. The results are given in Table II. It will be seen that the amount of water imbibed from notic solutions is nearly the same regardless of the kind ubstance dissolved. A difference of one atmosphere tic pressure decreased the amount of water absorbed average of 1.3 percent and ten atmospheres decreases 14.0 percent. Many cultivated soils in the arid region in sufficient salts to give a pressure of ten atmospheres sing the entrance of water into the seeds.

Solutions of sodium chloride were also used running up e hundred atmospheres calculated pressure. It appears when concentrated solutions are used an increase in the int of the salt does not produce its proportional effect. is, a small amount of alkali makes a decided difference e water imbibed but any additional salt does not make ich worse. One hundred atmospheres pressure shows ninution of 29.23 percent, about twice the effect pro- l by ten atmospheres. The irregularities in the strong ions are also very great, for example more water is im- l against 50 atmospheres than against 40.

The actual pressure tending to prevent the absorption ater by the seed is not nearly so great as the numbers ate for two reasons. One is that the formula only ap- to dilute solutions and the osmotic pressure becomes han the theoretical with increasing concentration, just

TABLE II.—*Imbibition of Water by Wheat From Solutions.*

No.	Solution	Strength per cent	Osmotic Pressure, Atmospheres	PERCENTAGE OF WATER ABSORBED.												Pure Water Absorbed, per cent.
				12 hours	24 hours	36 hours	48 hours	60 hours	72 hours	84 hours	96 hours	108 hours	120 hours	132 hours	144 hours	
1	Pure Water	0	0	33.1	42.6	49.2	51.6	54.6	55.7	58.3	60.1	60.1	61.7	62.3	62.3	
2	Sugar	1.43	1	33.4	43.2	49.3	51.3	54.3	55.2	58.2	59.8	60.8	61.4	62.0	61.7	
4	Magnesium Sulphate	.34	1	31.4	40.1	46.3	49.3	52.1	54.7	56.7	57.7	59.6	60.6	60.8	60.2	
6	Sodium Sulphate	.24	1	32.1	41.6	47.8	48.8	53.2	54.4	57.7	58.3	60.1	61.9	61.7	60.7	
8	Sodium Chloride	.12	1	34.0	41.9	49.5	50.0	51.8	53.7	56.9	57.9	58.3	59.1	59.3	60.3	
3	Sugar	14.30	10	26.4	27.9	41.8	44.2	45.0	46.0	46.7	47.8	48.1	48.1	48.1	47.9	
5	Magnesium Sulphate	3.94	10	31.2	38.4	43.3	45.5	45.9	46.9	47.9	48.9	48.9	48.9	48.7	47.7	
7	Sodium Sulphate	2.66	10	29.7	38.3	43.6	44.0	45.1	45.9	46.3	47.9	48.3	48.6	48.3	49.2	
10	Sodium Chloride	1.39	10	31.5	39.7	44.3	44.9	46.6	47.0	47.2	47.2	47.6	47.4	48.2	50.0	
9	Sodium Chloride	.67	5	29.6	38.0	42.6	43.4	45.0	47.4	49.6	51.4	51.1	51.4	52.4	53.8	
11	" "	2.83	20	28.7	37.6	41.9	43.4	44.2	45.0	45.8	46.2	46.6	46.2	46.4	47.1	
12	" "	4.34	30	25.4	35.7	38.2	40.3	41.6	42.2	42.6	43.1	44.1	43.5	43.9	44.1	43.1
13	" "	5.86	40	24.8	32.7	38.0	38.9	40.5	40.9	41.2	41.4	41.3	41.3	41.8	42.4	41.2
14	" "	7.56	50	20.8	28.7	34.4	35.4	38.0	30.4	40.0	40.4	41.0	41.0	41.8	43.4	41.5
15	" "	9.29	60	20.8	27.2	32.5	33.6	35.4	36.9	37.7	38.1	38.1	38.5	39.8	40.4	37.9
16	" "	11.00	70	17.8	24.9	29.8	32.3	32.3	33.7	35.1	35.9	36.7	36.8	37.9	39.1	37.7
17	" "	12.72	80	18.4	25.0	28.9	31.1	31.9	33.4	34.8	35.8	36.8	36.7	37.5	38.3	35.4
18	" "	14.44	90	18.7	23.0	27.4	30.3	32.4	33.5	35.5	36.1	37.1	36.9	37.9	39.1	35.9
19	" "	16.16	100	13.3	20.6	25.6	29.0	32.2	32.4	35.4	36.3	37.7	37.9	37.7	38.3	33.1

yle's law does not give correct results for condensed . The correction for this is not known, however, so eoretical numbers are given. Another point that must ken into consideration is that the seed is not semi-per- le in the technical sense. Salt is absorbed along with ater although not in the same proportion. The amount t absorbed by the wheat was determined in some of mples by incineration and titration and the quantity n in Table III, column five. The weight of grain taken ut five grams. In the next column the same thing is in percentages, and represents the number of grams t absorbed by 100 grams of wheat under the stated ic pressure. To ascertain how the strength of the salt on inside the seed compared with that outside, the tage of salt was calculated on the total amount of in the wheat, this amount being found by adding to ater absorbed, the water originally in the seed, which ut 10 percent.* This compared with the third column the relative concentrations of the salt solutions out- nd inside the seed, assuming of course that all the salt ed is held in solution. Calculating the osmotic pres- nside the grain due to the salt with that of the solu- utside gives column 8, the real osmotic pressure tend- prevent the imbibition of water. The osmotic pres- f the solution inside the grain due to other substances the salt absorbed is of course not known. With in- ng concentration the amount of salt absorbed with the continually increases although not in the same pro- n, so the net osmotic pressure also rises. From 50 pheres upward the true osmotic pressure is about half eoretical. This net osmotic pressure is, however, not d during the whole experiment but is only that at the The salt is absorbed gradually and accumulates so hibiting osmotic pressure is slowly and continuously

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oenig: Nahrungs-und Genussmittel, I, 471.

TABLE III.—*Effect of Solutions on Wheat.*

No.	Solution.	Strength per cent.	Osmotic Pressure, Atmospheres	Sodium Chloride in Soaked Seed.		Percentage of salt in water in wheat.	Net Osmotic Pressure, Atmo-pheres.	Volume before soaking, c. c.	Volume after soaking, c. c.	Increase in volume, per cent.	Specific gravity before soaking.	Specific gravity after soaking.
				Grams.	Per cent. of dry weight							
2	Sugar	1.43	1	.0022	.04	. .	. .	3.90	6.98	78	1.29	1.22
3	Sugar	14.30	10	. .	. .	. .	. .	3.91	6.56	67	1.29	1.20
8	Sodium Chloride	.12	1	.0013	.03	.03	.7	. .	. .	. .	1.29	. .
9	" "	.67	5	.0017	.03	.05	4.6	. .	. .	. .	1.20	. .
10	" "	1.39	10	.0088	.17	.25	8.0	. .	. .	. .	1.29	. .
11	" "	2.83	20	.0224	.43	.76	14.0	. .	. .	. .	1.29	. .
12	" "	4.34	30	.0545	1.07	2.00	15.8	3.92	6.22	58	1.29	1.23
13	" "	5.86	40	.0620	1.20	2.20	24.5	3.99	6.07	52	1.29	1.27
14	" "	7.58	50	.0946	1.87	3.50	25.6	3.91	6.06	55	1 29	1.26
15	" "	9.29	60	.1188	2.44	4.84	26.7	3.75	5.84	55	1.29	1.23
16	" "	11.00	70	.1513	3.07	6.25	27.7	3.81	5.66	48	1.29	1.28
17	" "	12.72	80	.1421	2.91	6.02	39.1	3.76	5.58	47	1.20	1.28
18	" "	14.44	90	.1636	3.25	6.58	45.8	3.89	5.53	44	1.29	. .
19	" "	16.16	100	.2675	5.31	11.00	30.0	. .	. .	. .	1.20	. .

ed. It will be seen accordingly from Table II that the solution exerts a greater influence at first than after- . At the end of twenty-four and thirty-six hours the is more regularly in inverse proportion to the osmotic re than later. The ratio of the amounts of water ped remains nearly constant throughout. At thirty- urs the wheat in the 100 atmosphere solution had ab- l 52.0 percent of the amount absorbed by that in pure and at 144 hours 53.1 percent. Evidently then the ce of salts in solution retards more than it prevents bibition.

he figures given in Table II are strictly speaking the ncrease of weight and include the salt as well as the absorbed. In the last column of this table the final s are corrected by substracting the weight of the salt ped and they are more regular than the uncorrected tages.*

he volume of the soaked wheat is reported in Table III nparison with the original volume of the wheat as ated from the specific gravity determination on a sin- mple. The increase in volume varies inversely with motic pressure like the increase in weight.

TION OF WATER FROM SALT SOLUTIONS BY VARIOUS SEEDS.

o see how great a difference there was in the behavior ferent kinds of seeds a series of tests were run with wer, peas, buckwheat, rape and Scirpus paludosus, n pure water and in solutions of sodium chloride of nd ten atmospheres osmotic pressure. Scirpus palu- is a native plant that grows readily in strong alkali d.

s Table IV shows, the presence of salts in solution ished the amount of water absorbed in all cases except sunflower, which shows a surprising variation from

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art of this table was published in Bull. No. 39, where, however, ding should be "Parts per Thousand" instead of "Percent".

TABLE IV.—*Imbibition of Water From Salt Solutions by Various Seeds.*

No.	Kind of Seed.	Per cent. of Sodium Chloride.	Osmostic Pressure, Atmospheres.	PERCENTAGE OF WATER ABSORBED.													
				12 hours	24 hours	36 hours	48 hours	60 hours	72 hours	84 hours	96 hours	108 hours	120 hours	132 hours	144 hours	156 hours	192 hours
1	Sunflower	0	0	83.4	95.5	110.2	115.4	121.3	126.8	131.4	132.7	138.0	137.8	136.9	137.1		
2	"	.67	5	74.3	89.2	99.2	103.8	110.6	113.6	122.1	127.3	129.8	131.1	131.1	131.0		
3	"	1.39	10	71.7	92.9	116.4	120.0	126.0	136.5	144.0	148.3	154.0	156.5	160.1	161.2		
4	Peas	0	0	82.4	91.0	98.2	101.4	104.2	108.3	110.1	110.8	117.0	117.3	120.1			
5	"	.67	5	68.8	76.1	80.1	83.3	85.6	89.9	92.2	93.2	95.0	96.9	100.6			
6	"	1.39	10	76.8	83.8	87.9	89.5	91.8	93.3	94.6	95.6	96.5	97.6	99.6			
7	Buckwheat	0	0	45.0	53 4	56.5	59.9	65.2	64.1	64.5	65.7	65.5	65 4	65.8	65.8	64.6	64.8
8	"	.67	5	42.0	44.8	46.7	48.4	53.8	52.8	53.4	54.0	53.8	52.8	53.8	53.4	53.2	54.0
9	"	1.39	10	30.9	43.3	46.3	47.3	49.8	50.5	51.1	51.3	52.5	50.1	50.5	50.7	50.9	50.7
10	Rape	0	0	53.7	54.7	56.7	57.0	57.7	58.3	59.0	60.0	63.0	58.3	58.3	57.7	57.3	
11	"	.67	5	48.7	49.0	51.0	50.7	50.7	50.7	51.3	52.7	53.0	49.7	49.7	50.0	50.3	
12	"	1.39	10	45.7	47.0	49.0	47.7	50.3	50.3	50 3	50.3	50.3	47.7	49.3	47.3	48.3	
13	Scirpus	0	0	23.3	23.3	27.0	28.3	31.0	30.6	32.0	32.3	33.3	30.3	32.3	31.6	32.0	32.6
14	"	.67	5	17.3	22.0	27.0	27.6	30.0	30.6	31.3	31.3	31.3	31.3	31.3	31.6	32.3	32.2
15	"	1.39	10	16.0	22.3	25.3	27.0	27.6	28.6	29.6	29.6	29.6	29.6	30.0	30.0	30.0	30.0

TABLE V.—*Effect of Sodium Chloride Solutions on Various Seeds.*

No.	Kind of Seed.	Percentage of salt in solution.	Osmotic Pressure, Atmospheres.	Salt in soaked seed Percentage on dry weight.	Percentage of salt in water in seed.	Net Osmotic pressure, Atmospheres.	Volume before soaking, c. c.	Volume after soaking, c. c.	Increase in volume, per cent.	Specific gravity before soaking.	Specific gravity after soaking.
1	Sunflower	0	0	.044	.03	.2	8.75	10.88	24.4	.575	1.055
2	"	.67	5	.155	.11	4.0	8.71	10.83	24.3	.575	1.059
3	"	1.39	10	.451	.27	8.1	8.78	12.43	41.5	.575	1.057
4	Peas	0	0	.044	.03	.2	3.76	10.34	175.0	1.326	1.067
5	"	.67	5	.506	.44	2.0	3.86	10.20	164.2	1.326	1.009
6	"	1.30	10	1.309	1.16	2.0	4.03	10.43	158.7	1.326	1.029
7	Buckwheat	0	0	.014	.02	.1	4.36	6.74	54.6	1.154	1.216
8	"	.67	5	.016	.03	4.8	4.35	6.41	47.4	1.154	1.243
9	"	1.39	10	.016	.03	9.8	4.33	6.33	46.0	1.154	1.191
10	Rape	0	0	.010	.02	.1	2.82	4.54	61.0	1.066	1.071
11	"	.67	5	.026	.04	4.8	2.82	4.33	53.6	1.066	1.076
12	"	1.39	10	.073	.13	9.1	2.82	4.32	53.1	1.066	1.077
13	Scirpus	0	0	.017	.05	.3	3.98	5.18	30.1	.753	.766
14	"	.67	5	.043	.12	4.2	3.98	4.66	17.0	.753	.850
15	"	1.39	10	.070	.20	8.6	4.74	5.34	31.2	.753	.729

what was expected. In Table V are given other data fr this experiment which show that all kinds of seeds abs more salt from strong than from weak solutions so that real osmotic pressure is somewhat reduced. This is v slight except in the case of peas, which admit the salt alm as freely as the water so that the net osmotic pressur reduced almost to zero. Peas in five and ten atmosph solutions absorbed practically the same amount of wa and the net osmotic pressure is really the same. All seeds except peas will grow well in alkali land. Scirpu a native alkali plant and the Russian sunflower has b recommended for cultivation because of its immunity fr the effects of alkalia. The rape and Scirpus seeds are so what alike in size and appearance and practically absor no more water after the fourth day. Sunflower and peas gan to sprout at the end of the experiment. The volume specific gravity determinations are of little interest. percentages of salt in the seeds after soaking in the tilled water given in the table are always less than in original seed, showing that some of the salts had b washed out. The percentages of water in the original s used in calculating column 6 of Table V are taken fr Keonig as follows: Buckwheat 14 percent, rape 7 perc sunflower 8 percent, peas 14 percent, corn 9 percent.

IMBIBITION OF WATER FROM SALT SOLUTIONS BY CORN WOOD.

An experiment on sweet corn with five isosmotic s tions of the common alkalies and sugar gave the s results as were obtained before on other seeds. (Tables and VII.) In all cases five and ten atmospheres osm pressure diminishes the amount of water absorbed. double check was run in pure water which shows that difference between different seeds due to surface structure is considerable. The irregularity due to this ca is greater with corn when the five grams contained

TABLE VI.—*Imbibition of Water From Salt Solutions by Corn and Wood.*

No.	Substance used	Solution of	Strength of solution, per cent.	Osmotic pressure atmospheres	PERCENTAGE OF WATER ABSORBED.												
					12 hours	24 hours	36 hours	48 hours	60 hours	72 hours	84 hours	96 hours	108 hours	120 hours	132 hours	144 hours	156 hours
1	Corn	Pure Water.	0	0	47.5	64.6	78.0	85.0	92.3	97.3	101.1	103.5	104.3	105.5	106.0	106.3	106.5
2	“		0	0	49.2	66.6	79.2	85.4	92.1	96.2	100.0	102.4	104.4	105.1	106.1	105.9	105.7
3	Corn	Sugar.	7.2	5	45.0	58.5	69.1	73.9	77.7	79.7	82.0	83.3	84.5	85.2	84.5	83.7	82.4
4	“		14.3	10	38.6	52.7	61.5	65.8	69.8	71.7	73.7	74.8	74.6	74.8	74.0	73.1	71.9
5	Corn	Magnesium Sulphate	1.85	5	46.1	62.9	75.1	80.6	85.3	90.7	92.2	94.3	96.5	97.7	98.5	99.5	97.7
6	“		3.94	10	39.1	52.3	64.7	69.2	73.7	78.4	80.1	81.6	83.6	84.8	85.3	85.7	85.5
7	Corn	Sodium Sulphate	1.23	5	46.1	63.5	77.5	81.5	87.6	92.2	93.5	96.9	98.9	98.9	96.7	96.5	94.9
8	“		2.86	10	43.7	58.8	70.2	75.9	81.4	84.5	88.6	90.2	91.4	92.5	92.2	93.5	93.1
9	Corn	Sodium Carbonate.	1.34	5	54.5	59.9	81.5	86.0	90.3	92.8	95.8	97.4	99.6				
10	“		3.87	10	48.5	63.0	72.6	76.6	79.2	80.6	80.6	81.7	83.0				
11	Corn	Sodium Chloride.	.67	5	45.6	60.6	71.8	79.4	85.8	90.0	89.8	96.4	98.8	99.6	99.8	99.6	99.8
12	“		1.39	10	39.9	55.9	65.4	70.2	75.8	79.2	80.7	84.7	86.3	87.5	88.1	88.3	89.1
13	“		2.83	20	39.3	52.8	63.7	68.9	74.1	78.4	82.8	85.6	88.6	90.4	92.0	93.4	95.0
14	“		4.34	30	35.0	46.5	54.8	59.2	63.6	66.9	70.4	72.9	75.6	77.9	79.6	81.5	82.5
15	“		5.86	40	29.6	38.1	46.5	50.7	55.9	59.3	64.0	67.9	72.2	73.0	75.1	77.3	79.7
16	“		7.58	50	26.6	37.6	45.5	49.4	55.9	60.2	65.1	69.0	71.9	76.9	79.8	83.3	86.9
17	Wood	Pure Water.	0	0	55.5	64.6	76.1	79.7	80.1	88.5	92.9	96.5	102.8	107.3	113.4	117.3	122.2
18	“	Sodium Chloride.	1.39	10	53.2	60.8	69.8	72.7	77.7	78.8	83.6	86.9	92.6	96.1	101.7	105.1	100.5

TABLE VII.—*Effect of Salt Solutions on Corn and Wood.*

No.	Substance used	Solution of	Strength, per cent.	Osmotic pressure atmospheres.	Salt after Soaking. Per cent of dry weight.			Percentage of salt in water absorbed.	Net osmotic pressure, atmospheres.	Volume before soaking, c. c.	Volume after soaking, c. c.	Increase in volume, per cent.	Specific gravity before soaking.	Specific gravity after soaking.
					Magnesium Sulphate.	Sodium sulphate	Sodium chloride.							
1	Corn	Pure water	0	0						4.42	10.57	139	1.138	1.085
2	"	Pure water	0	0						4.77	10.33	116	1.138	1.093
3	"	Sugar	7.2	5						4.64	9.10	96	1.138	1.068
4	"	Sugar	14.3	10						4.57	8.40	84	1.138	1.076
5	"	Magnesium Sulphate	1.85	5	.19			.19	4.5	4.48	9.34	108	1.138	1.087
6	"	Magnesium Sulphate	3.94	10	.48			.46	8.8	5.03	9.76	94	1.138	1.098
7	"	Sodium Sulphate	1.23	5		.90		.94	1.4	4.44	9.15	106	1.138	1.085
8	"	Sodium Sulphate	2.86	10		2.39		2.15	2.2	4.48	8.84	97	1.138	1.123
11	"	Sodium Chloride	.67	5			.28	.25	3.0	4.39	9.11	108	1.138	1.102
12	"	" "	1.39	10			.62	.56	5.8	4.42	8.71	97	1.138	1.099
13	"	" "	2.83	20			1.72	1.60	8.6	4.39	8.97	104	1.138	1.092
14	"	" "	4.34	30			2.55	2.99	8.0	4.57	8.57	88	1.138	1.115
15	"	" "	5.86	40			3.32	3.63	14.7	4.68	8.51	82	1.138	1.134
16	"	" "	7.58	50			5.00	5.16	14.6	4.48	8.13	81	1.138	1.179
17	Wood	Pure water	0	0						14.63	15.98	10.9	.358	.765
18	"	Sodium Chloride	1.39	10			.97	.88	3.6	14.54	15.74	10.7	.358	.733

y kernels than with such seeds as rape and Scirpus
the three grams used numbered over a thousand
. In the more concentrated solutions of sodium
de running up to fifty atmospheres the irregularities
forty-eight hours became noticeable but find a partial
nation in the amount of salt absorbed. The real osmotic
ure tending to prevent absorption of water was not
case fifteen atmospheres at the end of the experiment.
odium carbonate attacked the corn at once and disin-
ted the kernels so the tests in these solutions were soon
ed. To see whether physiological forces were con-
d in the imbibition of water before germination a par-
est was made with dry pine wood cut into cylinders
50 mm. long by 5 mm. diameter. Water is absorbed
ch the same way by wood as by seeds and the presence
t in solution diminishes and retards the imbibition.

t will be noticed that some of the salts are absorbed to
ch greater extent than others under originally the
"head" of osmotic pressure and this produces a dif-
e in the amount of water imbibed. It was thought
he forcing of the salt into the seed by osmotic pres-
nust be similar to forcing it through water by the ac-
f the same force and if so the salts would be absorbed
order of their diffusibility. Dividing the amount of the
absorbed per hundred weight of dry seed by the
alent weights gives the relative number of molecules
l into the corn in six and a half days, and these num-
nay be compared with the number of molecules forced
gh water in a given time by osmotic pressure as dis-
ed by Long.*

	No. of Molecules Diffused Through Water.	No. of Molecules Absorbed By Corn	
		5 Atmos.	10 Atmos.
um sulphate	678	132	303
chloride	600	43	95
nesium sulphate	348	31	76

appears from this that salts under the same os-

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stwald: Lehrbuch der allgemeinen Chemie, I, 691.

motic pressure are absorbed by seeds in the order of th diffusibility. The ratio is not exactly the same but th could not be expected under the crude conditions of t experiment in which the motive force was constantly cha ing.

In this as in the preceding experiments the speci gravity was taken from a single sample and the "volum before soaking" calculated from this. Doubtless it wou have been more accurate to have determined the volume each sample.

Plotting the curves of water absorbed in all the expe ments shows that the curve is more nearly a straight l the stronger the solution. That is, the seeds in pure wa absorb rapidly at first and soon cease while those in s solutions absorb water more slowly and regularly, conti ing to swell for a long time until they acquire nearly same amount as in pure water. This is in accordance w the theory that the osmotic pressure tends to prevent i bibition at first, and that, as this is lessened by the accun lation of salt inside the seed, the imbibition may contin Field work shows, too, that alkali retards rather than p vents germination and growth with many crops.

EFFECT OF ALKALI ON THE GERMINATION OF SEEDS.

In 1896 a series of experiments on the effect of alkali the germination of seeds was carried on, the results which were published in detail in Bulletin No. 29. T alkali used was that found on the Experiment Farm wh it amounts to 2.25 percent on "the alkali plats," or, assu ing 25 percent water in the soil, it is equivalent to a n percent solution, which was used in these experiments. T other solution was made up on the basis of one percent the soil or a four percent solution. The composition of alkali is:

Sodium chloride	14.39 perc
Sodium sulphate	50.16 perc

m sulphate ....15.41 percent
esium sulphate ....20.03 percent

he osmotic pressure of this solution could not be ex-alculated, as the pressure of a salt in a mixture is not me as when alone and the conductivity of calcium sul- is not known, but the osmotic pressures are not far .6 and 33 atmospheres respectively. Table VIII gives

LE VIII.—*The Effect of Alkali on the Germination of Seeds.*

Crop.	Per cent alkali in solution.	Osmotic pressure Atmospheres.	Per cent. germinated in			Number of days to germinate.	
			10 days.	15 days.	25 days.	50 per cent	90 per cent
	0	0	84	85	85	5	. .
	4	16	0	4	43	30	. .
	9	33	0	0	0	. .	. .
	0	0	98	98	98	3	4
	4	16	86	97	97	9	12
	9	33	3	25	42	. .	. .
	0	0	96	96	96	2	4
	4	16	89	91	94	3	11
	9	33	75	84	91	9	21
	0	0	72	94	94	8	12
	4	16	1	14	26	. .	. .
	9	33	. .	. .	. .	. .	. .
	0	0	85	88	92	5	16
	4	16	34	56	68	11	. .
	9	33	2	6	33	. .	. .
	0	0	100	100	100	5	6
	4	16	23	80	99	11	17
	9	33	1	1	3	. .	. .

nary of the results and shows that salts in solution and prevent germination in all cases but that there is difference in the extent of the deleterious effects of on different crops.

ERMINATION OF WHEAT AND RYE IN SALT SOLUTIONS.

determine what kinds of alkali and in what amounts nost deleterious a germination experiment was car-t by Mr. Fairfield under the direction of Prof. Buffum, ails of which are given in another part of this report. w in how far osmotic pressure was a factor in retard-rmination, Table IX has been drawn up, giving the r of seeds of wheat and rye germinated out of fifty in

TABLE IX.—*Effect of Salt Solutions on the Germination of Wheat and Rye.*

Solution of	Strength, per cent	Osmotic pressure.	Wheat.		Rye.	
			No. germinated in		No. germina in	
			2 days	3 days	2 days	3 d
Pure water	0	0	15	24	46	
Sugar	.1	.1	19	28	46	
Magnesium Sulphate	.1	.3	12	25	40	
Sodium Sulphate	.1	.4	12	19	47	
Sodium Carbonate	.1	.5	24	37	46	
Sodium Chloride	.1	.8	12	19	46	
Sugar	.4	.3	17	29	46	
Magnesium Sulphate	.4	1.2	11	30	45	
Sodium Sulphate	.4	1.6	13	33	47	
Sodium Carbonate	.4	1.8	3	21	38	
Sodium Chloride	.4	3.0	7	25	41	
Sugar	.7	.5	15	30	50	
Magnesium Sulphate	.7	2.0	15	31	47	
Sodium Sulphate	.7	2.8	6	23	46	
Sodium Carbonate	.7	3.1	3	21	38	
Sodium Chloride	.7	5.2	5	20	40	
Sugar	1.0	.7	12	31	47	
Magnesium Sulphate	1.0	2.8	11	29	45	
Sodium Sulphate	1.0	3.9	3	23	40	
Sodium Carbonate	1.0	4.3	0	6	26	
Sodium Chloride	1.0	7.4	0	9	32	
Sugar	2.0	1.4	15	20	40	
Magnesium Sulphate	2.0	2.8	7	17	34	
Sodium Sulphate	2.0	7.5	2	12	32	
Sodium Carbonate	2.0	8.1	0	1	6	
Sodium Chloride	2.0	14.2	0	5	17	
Sugar	3.0	2.1	16	25	47	
Magnesium Sulphate	3.0	7.7	4	20	42	
Sodium Sulphate	3.0	11.1	0	9	14	
Sodium Carbonate	3.0	11.6	0	0	2	
Sodium Chloride	3.0	21.1	0	0	1	
Sugar	4.0	2.8	16	30	42	
Magnesium Sulphate	4.0	10.2	0	11	19	
Sodium Sulphate	4.0	13.7	0	7	3	
Sodium Carbonate	4.0	15.0	0	0	1	
Sodium Chloride	4.0	27.7	0	0	0	
Sugar	5.0	3.5	14	24	46	
Magnesium Sulphate	5.0	12.6	0	3	15	
Sodium Sulphate	5.0	17.0	0	0	0	
Sodium Carbonate	5.0	18.4	0	0	0	
Sodium Chloride	5.0	34.3	0	0	0	
Sugar	7.0	4.9	7	22	43	
Magnesium Sulphate	7.0	17.2	0	1	8	
Sodium Sulphate	7.0	23.3	0	0	0	
Sodium Carbonate	7.0	20.1	0	0	0	
Sodium Chloride	7.0	46.6	0	0	0	

two and three days in comparison with the osmotic press
tending to prevent the necessary preliminary absorpt
of water. The results are very irregular, partly on

t of individual peculiarities of the seeds and partly use concentration of the solutions in contact with seeds could not be as accurately maintained as the other experiments. In most cases the num germinated in two or three days is in inverse or to the osmotic pressure. At the end of five or days, as may be seen from the complete tables, how, there is little difference noticeable, showing that in e solutions the alkali retards but does not prevent ger ation. Stronger solutions prevent the germination of y of the seeds altogether. Sodium carbonate in very e solutions seems to stimulate germination, in stronger tions it destroys the seed. Rye is not so much affected lkali as wheat. Five atmospheres osmotic pressure by tever salt it may be produced interferes seriously with germination of wheat during the first three days and tmospheres prevents it almost entirely. Ten and fifteen ospheres pressure produce a corresponding effect on

ANALYSES OF WYOMING ALKALI.

Several analyses of alkali from various parts of the that have not previously been reported are given in e X. The samples are in most cases simply the white sit on the ground to the depth of an inch or two, so the

TABLE X.—*Analyses of Wyoming Alkali.*

Place and Date.	Percentage of alkali in soil.	Percentage composition.			
		Sodium sulphate	Sodium Chloride	Mag. sulphate	Sodium carbon-ate.
vo miles west of Lander, June '97	17.01	51.61	1.96	46.43	. . .
nd River Board School Garden, June '97	15.34	82.55	8.39	9.06	. . .
l'e Springs, 15 miles north of Rawlins, June '97	3.72	29.35	17.42	53.23	. . .
miles north-west of Rawlins, June '97	.08	57.20	28.40	14.40	. . .
ffalo school grounds, '96	7.62	96.20	1.19	2.61	. . .
tter Creek bed, June '97	8.00	89.51	6.89	3.60	. . .
int of Rocks, near Bitter Creek, June '97	.86	25.90	74.10	. . .	. . .
enda Buttes, September '97	7.20	50.41	4.08	. . .	45.51
y pond near Granger, June '97	63.90	75.98	3.57	20.45	. . .
ne farm, 1891	1.82	13.58	56.18	30.24	. . .

percentage of alkali in the soil as given does not mean anything very definite.

In reporting these analyses, calcium sulphate has bee excluded for the following reasons: First, it is never injurious and even a saturated solution of it is probably beneficial. Second, the amount of calcium sulphate reported a alkali depends merely on the method of extraction. In al parts of the state, except in the carbonate region, the soi contains a large amount of gypsum and if the soluble salt are extracted by percolation, one may continue to dissolv it indefinitely. If the other method is used, of shaking u say one hundred grams of soil in two hundred cubic centimeters of and filtering a portion for analysis, the amount o calcium sulphate obtained is still dependent on the propo tions of soil and water. There should be an official defin tion and method of extraction for alkali adopted by the A sociation of Official Agricultural Chemists. As it is no there are so many ways of reporting soluble salts, that con parison of published analyses is very difficult. In the a alyses here given calcium sulphate has been determine subtracted, and the result recalculated on the basis of tru soluble salts.

DISCUSSION OF RESULTS.

The temptation to theorize from these incomplete r sults could not be entirely resisted, but speculation h been confined to the following paragraph: That wat should be absorbed by a seed or plant from a solution o fering a great opposing osmotic pressure is not surprisi when we consider the enormous forces concerned in im bition. The wetting of blocks of wood is used for splitti granite rocks and raising buildings. Internal osmotic pre sures of living plant cells has been measured to twenty a mospheres.*

That the forces concerned in the absorption of wat

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*Noll: Lehrbuch der Botanik fur Hochschulen, p. 139.

lts by the seed and probably by the plant roots are
al or chemical rather than physiological* is evident,
is not yet known exactly what they are. The fact
ie salts absorbed from soil solutions are not always
me as those reported by chemical analysis to be in
ution, was a source of great perplexity to the older
sts, who were obliged to ascribe very remarkable
ve powers to the root hairs. According to the modern
of solutions this offers no difficulty since it is known
lts do not exist as such in solutions but in their ionic
The experiments here given indicate some relation
n the diffusibility of salts and their absorption by
If further experiment shows this to be general and
ble also to roots it would apparently give foundation
heory of the selective absorption of salts by plants.
ium for example has a migration velocity of 59.7 com-
to 41.1 for sodium, which may account for potassium
aken up by the plant in preference to sodium, regard-
their original proportions in the soil. It has long
nown but never explained, that the presence of non-
ve salts in the soil influences to the marked degree
sorption of plant food. Now it is found that the dif-
ity of a salt is different when mixed with other salts
hat it is when alone. When two salts are in solution
er the more rapid is accelerated and the slower is re-
both absolutely and relatively.§ For example: The
n of gypsum to the soil would therefore increase the
t of potassium diffused into a plant, a result which
ccordance with fertilizer practice and suggests the
lity that a rational system in the use of fertilizers
ventually replace the present empiricism. It would
to calculate exactly what salts added to a soil solu-

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e word physiological is used here in its customary sense to in-
enomena of life not otherwise classified. It is a euphemism for
e like the word chance in physics and fate in metaphysics.

twald: Lehrbuch der allg. Chemie, I, 696.

tion would produce the greatest acceleration to the nut tious elements and retard the deleterious. Selction abso tion of salts is of course not a property of living matt alone. Charcoal, soil, sand or filter paper will absorb certa salts from a solution and leave others or even take out t basic party of a salt, leaving the solution acid.* Ionic mig tion velocities and absorption will certainly go far towa explaining the phenomena of plant nutrition. If the posit ions diffuse into the plant more rapidly than the negati ions, there would be a difference of electrical potential, a the soil solution around the roots would become acid. Bo these phenomena have been observed, but it has been su posed that the root hair "excreted" the acid which is al to decompose granite fragments. It would seem a possil hypothesis that this acid, which is equivalent to hyd chloric acid of 1.115 specific gravity, might be produced the acid radicles left behind in the soil when the posit ions entered the plant.

A difficulty in the way of the study of the effects salts in solution on plants and seeds that will probably p vent any exact numerical relations being established tween the concentration, the solution and the imbibition water, is that owing to absorption the concentration of solution on the surface of seeds, roots and soil grains is the same as that of the free solution. No method for termining the correction to be applied for this is at pres known.

So much attention has been given to injurious effects alkali that it has generally been overlooked that the ab dance of soluble salts in the soil is of benefit in several w to plants that can stand it. There is always more water alkali soils than in other, partly because it lessens evap tion. The evaporation from a 16.16 percent solution of c mon salt calculated from the vapor pressure is eight perc han from pure water.* Whether the same ratio holds ie evaporation from soil wet with pure water and with olutions is not known. Plants growing in alkali land a large amount of salts in their sap. This helps the to acquire water from the soil by increasing the in- l osmotic pressure and also to preserve its water by ing transpiration. It would seem better policy to try ow agricultural plants that can endure and use the i as some weeds can, rather than to attempt to elim- it from the soil. Experiments have proved that it is ble to accustom certain of the lower plants and als to different osmotic pressure of the surrounding im.§ It is possible that something could be done with l plants in the way of acclimatizing them to the arid n either by selection or development.

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*Ostwald I, 1094.

FUTURE WORK.

number of experiments have been carried out on the h of plants in salt solutions on the same lines as those bibition and germination but will be continued another before publication. More work will also be done in bsorption of water and salts by seeds and plants to he theories here suggested, particularly in regard to velocities and the effect of solutions of mixed salts. ses of plants immune to the bad effects of alkali are made in connection with the study of the botanist of ation on their structure. When the cause of immunity re thoroughly understood, experiments on the ac- nation of useful plants to the conditions of the arid n will be conducted in a more extensive and systematic han is being done here at present. Experiments on ration from solutions, from soils containing alkali rom plants in such soils are now under way. There is

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ernst: Theoretical Chemistry, p. 226.

he best resume of the work done on the relation of osmotic pres- plant life is found in Davenport; Experimental Morphology, and II.

much need of light on the subject of the effect of soil sal on transpiration.*

The above statement of the work we are undertakin is published for the purpose of putting us in communicatio with other stations working on the same problems. Th possible lines of investigation are so much more numerou than the workers that it is a great pity the labor shoul be wasted in duplication because of lack of coöperation.

SUMMARY.

Experiments on the imbibition of water by a large num ber of different kinds of seeds show that in all cases th presence of salts in solution hinders the absorption of wate Isosmotic solutions produce nearly the same effect, show ing that the osmotic pressure is more important than th kind of salt. Retardation of imbibition does not increas proportionally with the osomotic pressure or with the con centration of the solution, but less rapidly. An osmot pressure of five or ten atmospheres retards the imbibitio of water to a considerable extent with all seeds and in dilut solutions a difference of one atmosphere makes a percept ble difference in most cases. Salts are absorbed from sol tion by seeds but not in the proportion in which they exi in the water. The accumulation of salt in the seed gradual, so the osmotic pressure of the solution in the see tends to approach that outside. That the imbibition water is not due to the action of life is shown by the fa that similar results are obtained from living and dead seed and dry wood. Dilute solutions of the common alkali sal do not poison the seed or prevent its germination when th conditions become more favorable. Different salts are a sorbed from solutions in proportion to their diffusibilit The percent of water imbibed by seeds in distilled water b fore their germination is as follows: Corn 106, sunflow eas 120, buckwheat 65, rape 57, scirpus 33, wheat 62. ermination of seeds in various salt solutions gives resimilar to those on the imbibition of water. Wyoming consists principally of sodium sulphate, sodium ide and magnesium sulphate in varying proportions, some parts of the state the magnesium sulphate is ced by sodium carbonate.

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*Maxwell's results (American Chem. Journal, XX, 469) are in dir contradiction to the statements in the text books.

METEOROLOGICAL REPORT

—FOR THE YEAR—

nning January 1, and Ending December 31, 1898

BY C. B. RIDGAWAY.

Meteorological Report For 1898.

The work of the meteorological department has bee continuation of that of previous years. Observations u atmospheric conditions and soil temperature at vari depths have been taken twice daily, at 7 a. m. and 7 p. m.

The observations have been reported monthly to t United States Weather Bureau at Washington, and to t Wyoming Section at Cheyenne. Weekly climate and c reports have also been sent to the Cheyenne office.

The latitude of the Station is 41° 18′ 37.09″ North, a the longitude 105° 34′ 53.75″ West from Greenwich. T altitude of the standard barometer is 7,191 feet.

The equipment of the Station for meteorological servations consists of the following: A quadruple regis with two automatic pens for registering the velocity and rection of the wind; a Draper's self-recording thermo ter; a standard mercurial barometer; one Richard's s registering aneroid barometer; a sling psychrometer; soil thermometers at different depths in the ground; a ma mum and a minimum self-registering thermometer, a h gauge and evaporation tank; a standard eight-inch r gauge; a maximum and a minimum self-registering solar diation thermometer.

Summary.

Highest temperature, 88, June 30 and July 26.
Lowest temperature, —23, January 26.
Mean temperature for the year, 38.3.
Greatest daily range of temperature, 57, June 29.

Lowest daily range, 3, February 22.

Mean daily range of temperature for the year, 26.4.

Mean relative humidity for the year, 57.6.

Lowest relative humidity, 13, July 26 and September 19.

Highest dew point, 58, July 10.

Lowest dew point, —21, December 9.

Mean dew point for the year, 23.8.

Greatest terrestrial radiation, 12, June 11.

Mean terrestrial radiation for the year, 3.9.

Highest barometer, 23.408.

Lowest barometer, 22.47.

Mean barometer for the year, 23.020.

Highest monthly precipitation, 1.88 in., in June.

Lowest monthly precipitation, traces in September.

Highest precipitation during any single storm, .55 in., ust 4.

Total precipitation: 1891, 13.92 in.; 1892, 12.73 in.; 3.84 in.; 1894, 7.63 in.; 1895, 11.15 in.; 1896, 10.75 in.; 11.99 in.; 1898, 7.63 in.

Mean precipitation for eight years, 9.95 in.

Evaporation, 41.40 inches, from April 15 to October 15.

Greatest monthly evaporation, 10.33 inches in June.

Mean soil temperatures: 3 in., 42.3; 6 in., 44.3; 12 in., 24 in., 44.8; 36 in., 45.3; 72 in., 44.5.

Prevailing direction of the wind, southwest.

Greatest velocity of wind, 60 miles per hour.

Total number of miles traveled by wind during the yea days), 99,571.*

Greatest number of miles traveled in one month, 11,118, arch.

Lowest number of miles traveled in one month, 4,854, ugust.

Average number of miles for each month 8,297.6.

Greatest number of miles in one day, 700, October 3.

Least number of miles in one day, 24, August 17.

Mean daily distance traveled, 283.7.

Mean hourly distance traveled, 11.8.

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*While the instrument tower was being moved farther back from ildings, and at other times, the wind record was incomplete. If ltiply 283.7 miles, the daily average, by 365, the number of days in a t will give 103,505 miles, which is very near the correct number of for the year.

TABLE I.*—*Temperature, 1898.*

	JANUARY.						FEBRUARY.						MARCH.					
Date.	7 a.m.	7 p.m.	Max.	Min.	Mean.	Daily Range.	7 a.m.	7 p.m.	Max.	Min.	Mean	Daily Range.	7 a.m.	7 p.m.	Max.	Min.	Mean	Daily Range.
1	10	10	25	—12	7	37	9	21	29	3	16	26	25	25	37	23	30	14
2	28	35	38	4	21	34	8	21	31	7	19	24	23	25	38	16	27	12
3	31	23	**47**	23	35	24	24	31	41	17	29	24	22	35	49	15	32	34
4	12	20	32	8	20	24	17	19	28	17	22	11	30	34	43	23	33	20
5	21	33	41	10	25	31	25	43	48	17	33	31	31	29	40	25	32	15
6	20	30	43	20	32	23	33	39	43	27	35	16	26	33	50	16	33	34
7	30	28	37	22	30	15	23	32	44	20	32	24	36	42	**52**	21	36	32
8	25	24	38	21	29	17	25	28	44	22	33	22	33	15	49	17	33	32
9	15	28	37	12	20	25	24	20	29	19	25	10	28	28	42	15	29	27
10	21	25	43	15	29	28	5	24	32	4	18	28	20	22	35	17	26	18
11	7	10	27	4	15	23	8	20	34	5	20	29	8	21	28	2	15	26
12	6	11	27	4	11	31	24	30	40	14	27	26	18	28	34	16	25	18
13	10	14	31	—3	14	34	13	32	38	8	23	30	31	37	48	23	35	25
14	8	6	18	4	11	14	34	35	36	**2**	19	**34**	17	17	23	15	19	**7**
15	9	18	27	—1	13	28	34	37	38	32	35	6	19	20	32	12	22	20
16	11	17	28	10	19	18	29	35	**49**	26	38	23	15	25	39	11	25	28
17	11	14	19	8	14	11	9	16	25	7	16	18	26	35	50	14	32	36
18	—1	10	21	—3	9	24	10	19	28	7	17	21	33	21	40	15	33	25
19	15	18	27	6	16	21	20	15	27	12	20	15	18	23	30	11	20	19
20	4	11	18	—1	8	19	22	32	32	8	20	24	24	26	38	18	28	20
21	1	3	15	—4	5	19	20	35	35	16	26	19	26	4	40	12	21	38
22	13	20	25	—4	11	29	22	18	20	17	19	**3**	—6	—7	4	—6	—1	10
23	12	17	18	5	11	13	9	30	30	7	18	23	7	22	30	**—10**	10	**40**
24	5	2	7	0	3	**7**	16	38	37	13	25	24	27	34	47	20	34	27
25	—4	—4	9	—10	0	19	38	35	40	32	26	8	37	41	50	25	37	25
26	—3	12	15	**23**	-4	**38**	24	32	46	21	36	25	35	19	46	20	33	26
27	18	28	34	10	22	24	26	29	45	17	31	28	8	20	46	14	30	32
28	5	19	25	14	20	11	33	37	48	22	35	26	19	23	46	7	26	39
29	26	25	33	25	29	8							13	22	37	7	22	30
30	20	21	31	20	25	11							19	25	33	7	30	26
31	19	20	34	20	27	14							25	26	35	12	24	23
Sum.	385	548	870	196	527	674	584	803	1017	419	713	598	693	773	1211	433	831	778

Date.	7 a.m.	7 p.m.	Max.	Min.	Mean.	Daily Range.	7 a.m.	7 p.m.	Max.	Min.	Mean.	Daily Range.	7 a m.	7 p.m.	Max.	Min.	Mean.	Daily Range.
1	18	28	42	10	26	32	26	26	29	24	27	5	58	64	74	38	55	36
2	40	46	61	18	40	43	27	30	38	21	29	17	61	65	76	44	60	32
3	36	22	60	22	41	38	28	28	35	26	31	**9**	48	47	54	36	45	18
4	25	22	40	15	27	25	25	30	37	24	30	13	27	42	48	33	41	15
5	18	20	42	**2**	22	40	30	31	38	23	31	15	42	49	58	**29**	44	29
6	21	36	50	10	30	40	33	39	52	**20**	36	32	45	51	61	34	47	27
7	31	34	43	25	34	18	44	43	59	29	44	30	47	50	63	36	50	27
8	33	40	48	26	37	22	35	39	54	31	42	23	50	51	60	41	50	19
9	38	41	55	26	36	31	38	49	59	31	45	28	52	51	63	40	52	23
10	43	49	62	24	43	38	47	56	65	30	47	35	50	47	70	35	52	35
11	41	36	51	30	40	21	54	45	66	41	54	25	52	49	64	42	53	22
12	32	37	48	28	38	20	46	47	59	34	46	25	53	54	65	41	53	24
13	38	49	61	26	44	35	50	47	62	38	50	24	52	58	60	48	54	**12**
14	47	56	67	35	51	32	45	45	57	31	44	26	55	57	69	46	57	23
15	33	54	72	27	50	**45**	48	47	59	34	46	25	57	68	73	44	59	29
16	45	48	69	42	55	27	46	41	55	40	48	15	60	67	79	43	61	36
17	38	41	44	30	37	14	40	38	49	31	40	18	64	68	82	42	67	40
18	35	45	56	23	40	33	44	44	55	42	49	13	61	68	79	49	64	30
19	36	42	56	28	42	28	45	40	49	33	44	23	65	61	75	43	59	32
20	48	49	62	33	48	29	38	49	49	33	41	16	64	63	84	44	64	40
21	48	39	48	33	40	15	40	50	58	29	44	29	60	72	83	39	61	44
22	43	44	50	29	39	21	53	67	71	28	48	**43**	66	64	85	45	65	40
23	41	39	51	31	41	20	57	65	**73**	32	53	41	62	62	76	46	61	30
24	38	46	56	23	40	33	48	45	65	33	50	29	62	69	76	44	60	32
25	43	55	66	25	46	41	47	52	57	38	47	19	64	69	78	48	63	30
26	56	63	**74**	39	57	35	46	47	51	43	47	18	57	68	76	48	42	28
27	39	36	47	36	40	**11**	49	51	65	38	52	27	59	73	81	38	59	43
28	40	51	60	24	42	36	48	48	58	40	49	18	68	73	87	38	63	49
29	46	35	57	34	45	23	47	57	62	37	50	25	60	66	86	**23**	57	**57**
30	34	32	43	30	37	13	58	52	68	35	51	33	72	75	**88**	44	66	44
31							45	54	62	40	51	22						
Sum.	1124	1236	1641	784	1208	859	1328	1404	1716	1012	1366	721	1693	1821	2173	1227	1685	946
Mean.	37.5	41.2	54.7	26.1	40.3	28.6	42.8	45.3	55.3	32.6	44.1	23.2	56.8	60.7	72.4	40.9	56.8	31.5

TABLE I (Continued).—*Temperature 1898.*

	JULY.						AUGUST.						SEPTEMBER.					
Date.	7 a.m.	7 p.m.	Max.	Min.	Mean.	Daily Range.	7 a.m.	7 p.m.	Max.	Min.	Mean.	Daily Range.	7 a.m.	7 p.m.	Max.	Min.	Mean.	Daily Range.
1	54	59	73	**38**	55	35	51	53	67	42	54	25	61	61	72	54	63	18
2	59	57	65	50	57	15	50	63	72	**38**	55	34	60	57	76	50	63	26
3	55	61	70	58	64	**12**	52	75	81	41	64	34	52	57	71	42	56	29
4	60	73	83	67	75	16	68	62	85	55	70	30	50	60	71	39	55	32
5	66	67	79	50	64	29	58	49	68	48	58	20	53	38	71	37	54	34
6	64	67	79	50	64	29	48	54	67	47	57	20	34	48	60	23	42	37
7	65	71	82	65	73	17	53	59	68	50	59	**18**	46	48	71	34	52	37
8	64	60	79	52	65	27	52	62	77	43	60	34	42	55	69	34	52	35
9	64	68	83	59	71	24	59	64	77	42	59	35	36	34	42	32	37	**10**
10	65	70	80	63	72	17	55	58	77	44	60	33	43	34	43	30	37	13
11	62	66	80	63	72	17	55	64	78	44	61	34	32	38	50	**19**	35	31
12	64	65	77	53	65	24	55	60	83	43	63	40	32	42	65	20	42	45
13	66	70	81	55	68	26	60	69	81	44	62	37	39	49	65	25	45	40
14	62	69	80	50	65	30	61	67	80	51	65	29	49	55	73	30	52	43
15	60	64	81	49	65	32	63	69	82	45	63	37	49	63	73	35	54	38
16	56	70	80	48	64	32	58	59	75	45	60	30	43	47	60	40	50	20
17	67	68	78	53	65	25	58	63	79	50	64	29	47	60	76	36	56	40
18	68	71	79	47	63	32	55	74	85	41	63	**44**	51	60	75	38	56	37
19	60	67	74	51	62	23	57	68	85	55	70	30	44	65	72	34	53	38
20	57	65	75	47	61	28	64	70	82	55	67	29	57	61	71	34	52	37
21	63	71	80	47	64	33	62	64	84	53	68	37	53	55	76	46	61	30
22	62	74	84	48	66	36	56	67	78	54	66	24	49	60	75	37	56	38
23	65	62	81	49	65	32	59	62	74	51	62	23	54	55	71	49	60	22
24	62	67	74	49	62	25	52	67	81	41	61	40	45	58	77	38	58	39
25	62	73	84	52	73	32	55	62	83	42	62	41	43	55	78	34	56	44
26	59	76	**88**	50	69	38	54	70	85	42	64	43	42	60	**79**	34	56	**45**
27	63	72	84	47	65	37	61	55	84	48	65	35	54	54	75	41	58	35
28	68	72	85	46	65	**39**	60	65	80	48	64	32	45	57	70	36	53	34
29	65	62	77	43	62	31	61	70	**83**	50	68	33	38	45	55	34	44	21
30	54	52	76	43	60	30	69	65	85	55	70	30	49	60	72	28	50	44
31	59	58	68	44	56	24	60	57	78	55	66	23						
					[illegible]	[illegible]	[illegible]	1995	2417	1452	1951	967	1395	1590	2055	1033	1558	902

Date	7 a.m.	7 p.m.	Max	Min.	Mean.	Daily Range.	7 a.m.	7 p.m.	Max	Min.	Mean.	Daily Range.	7 a.m.	7 p.m.	Max.	Min	Mean	Daily Range.
1	55	42	68	53	60	15	32	31	45	25	35	20	20	23	29	17	23	12
2	30	35	49	28	39	21	39	32	51	21	36	30	20	13	21	14	17.5	**7**
3	31	42	48	26	37	22	36	45	55	27	41	28	4	—1	17	—2	7.5	19
4	29	37	48	23	35	25	37	40	50	33	41	17	16	25	33	—3	15	36
5	31	40	52	28	40	24	32	35	48	22	35	26	25	8	35	7	21	28
6	32	41	66	27	47	39	41	45	**61**	20	41	41	0	11	21	—7	7	28
7	38	45	61	32	46	29	46	20	39	20	30	19	15	12	19	8	13.5	11
8	33	47	70	23	46	47	14	0	22	—1	11	23	—4	—10	5	—12	—3.5	17
9	43	41	53	38	48	20	1	8	18	**—12**	3	30	—21	—10	1	**—22**	—10.5	23
10	38	44	56	34	45	22	19	30	35	6	20	29	—10	—6	12	—19	—3.5	31
11	43	53	63	38	51	25	3	13	22	0	11	22	—8	7	25	—11	7	36
12	39	40	49	37	43	12	—4	13	21	—6	8	27	14	0	32	6	19	26
13	28	44	68	19	44	**49**	3	5	20	—1	9	21	9	21	37	—4	16.5	**41**
14	45	53	**69**	30	49	39	9	18	35	1	18	34	12	15	42	6	24	36
15	35	27	55	26	40	29	21	35	40	17	28	23	10	14	27	—4	11.5	31
16	24	25	31	11	21	20	18	19	31	16	24	15	14	22	39	5	22	34
17	17	29	40	13	27	27	24	33	34	17	25	17	8	14	42	3	22.5	39
18	34	31	41	25	33	16	35	36	46	32	39	14	2	19	39	0	19.5	39
19	24	19	27	16	22	**11**	34	38	57	35	46	22	14	27	39	0	19.5	39
20	19	23	30	**7**	19	23	36	2	45	2	23	**43**	24	27	30	15	22.5	15
21	23	36	47	13	30	34	—2	6	10	—4	3	14	13	7	18	1	9.5	17
22	35	46	60	30	45	30	15	15	25	—4	10	29	8	13	18	3	10.5	15
23	43	39	54	35	45	19	12	19	27	8	18	19	3	4	14	—1	6.5	15
24	27	21	41	21	31	20	19	16	23	8	16	15	9	9	21	0	10.5	21
25	16	30	44	12	28	32	12	20	34	5	19	29	21	21	31	9	20	22
26	34	45	58	27	42	31	10	25	47	13	30	34	26	30	36	21	28.5	15
27	33	38	50	30	40	20	22	28	37	16	28	21	28	31	42	31	36.5	11
28	36	28	44	26	45	18	28	20	30	15	23	14	29	35	**45**	28	36.5	17
29	16	29	47	13	30	34	20	28	28	15	22	13	18	4	18	4	11	14
30	35	49	62	21	42	41	17	21	27	17	22	**10**	10	2	13	—14	—.5	27
31	44	49	60	41	50	19							—5	4	11	—7	2	18
Sum.	1010	1168	1611	813	1220	803	629	696	1063	366	715	699	315	395	862	72	442	740
Mean.	32 6	37.7	51.9	26.2	39.3	25.9	20.6	23 2	35.4	12.2	23.8	23.3	10.2	12.7	25.9	2.32	14.3	23.0

TABLE II.—*Terrestrial Radiation.*

Date.	JANUARY			FEBRUARY			MARCH			APRIL			MAY			JUNE		
	Min.	Ter. Ther.	Rad.	Min.	Ter. Ther.	Rad.	Min.	Ter. Ther.	Rad.	Min.	Ter. Ther	Rad	Min	Ter. Ther.	Rad.	Min.	Ter. Ther.	Rad.
1	—12	—16	4	3	0	3	24	21	3	10	16		24	20	4	38	34	4
2	4	0	4	10	7	3	16	11	5	17	15	2	22	20	2	44	43	1
3	24	18	6	18	14	4	15	12	3	30	29	1	23	23	0	38	36	2
4	8	4	4	21	19	2	23	21	2	9	0	9	25	25		33	32	1
5	11	5	6	19	14	5	25	22	3	12	3	9	23	22	1	29	25	4
6	24	16	8	27	27	0	16	12	4	10	8	2	20	16	4	34	37	
7	22	16	6	23	18	5	18	15	3	28	28	0	30	25	5	36	37	
8	21	19	2	25	18	7	32	28	4	29	23	6	31	28	3	41	36	5
9	13	9	4	22	20	2	15	11	4	27	20	7	31	29	2	40	37	3
10	15	12	3	4	0	4	18	18	0	24	16	8	30	26	4	35	31	4
11	5	2	3	5	—1	6	6	4	2	31	26	5	41	37	4	43	31	12
12	—4	—6	2	18	14	4	16	14	2	29	27	2	35	33	2	42	37	5
13	—3	—4	1	9	3	6	24	22	2	27	22	5	38	35	3	43	39	4
14	6	4	2	18	29		16	18		35	31	4	32	29	3	47	44	3
15	0	—3	3	32	30	2	13	12	1	27	21	6	35	34	1	44	40	4
16	10	8	2	27	24	3	12	6	6	34	27	7	42	41	1	43	38	5
17	8	7	1	7	3	4	16	19		30	24	6	32	28	4	43	40	3
18	—2	—5	3	8	5	3	17	12	5	24	21	3	38	37	1	49	45	4
19	7	5	2	15	11	4	13	8	5	29	24	5	32	28	4	53	47	6
20	0	—1	1	8	5	3	19	17	2	33	31	2	34	32	2	45	42	3
21	—4	—9	5	17	10	7	18	14	4	37	30	7	31	24	7	36	33	3
22	—4	—5	1	21	16	5	—8	—7	1	31	28	3	29	26	3	45	42	3
23	5	1	4	7	4	3	—10	—11	1	31	27	4	28	22	6	45	45	0
24	4	0	4	13	9	4	20	14	6	23	20	3	36	33	3	46	44	2
25	—10	—11	1	32	28	4	25	16	9	25	21	4	38	35	3	50	48	2
26	—23	—27	4	21	14	7	26	21	5	39	36	3	43	42	1	41	38	3
27	10	8	2	17	13	4	14	18		37	35	2	39	36	3	40	38	2
28	4	—2	2	22	16	6	7	6	1	24	18	6	41	41	0	41	38	3
29	19	12	7				8	2	6	39	35	4	37	33	4	36	29	7
30	20	15	5				8	5	3	30	32		36	35	1	54	44	10
31	20	14	6				12	10	2				41	45				
Sum	198	86	104	469	370	110	474	391	94	811	694	125	1020	943	81	1258	1154	108

Date.	JULY			AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			DECEMBER		
	Min.	Ter. Ther.	Rad.	Min.	Ter. Ther.	Rad.	Min.	Ter. Ther.	Rad.	Min.	Ter. Ther.	Rad.	Min.	Ter Ther.	Rad.	Min.	Ter. Ther.	Rad.
1				42	40	2	54	50	4	53	51	2	25	21	4	17	11	6
2				38	44		51	45	6	28	20	8	21	13	8	20	17	3
3				47	49		42	39	3	26	20	6	28	22	6	6	0	6
4				55	48	7	39	30	9	23	19	4	33	22	11	−3	−5	2
5				52	43	9	37	30	7	28	19	9	22	17	5	26	20	6
6				47	45	2	23	19	4	22	15	7	20	25		−6	−13	7
7				46	42	4	34	28	6	32	29	3	37	30	7	9	6	3
8				44	43	1	26	21	5	23	18	5	13	13		−8	−13	5
9				47	42	5	32	32		39	20	10	−12	−15	3	−22	−29	7
10				44	41	3	30	29	1	35	29	6	6	3	3	−19	−25	6
11				44	42	2	20	14	6	37	31	6	0	−5	5	−11	−16	5
12	53	49	4	43	41	2	20	17	3	38	31	7	−5	−10	5	6	0	6
13	55	52	3	44	42	2	25	20	5	19	16	3	0	−4	4	4	4	
14	50	46	4	51	48	3	31	27	4	30	27	3	1	−10	9	12	3	9
15	49	44	5	45	42	3	35	32	3	35	35		17	8	9	−4	−8	4
16	48	45	3	45	44	1	40	32	8	11	12		16	12	4	5	−3	8
17	54	49	5	50	48	2	36	32	4	15	13	2	11	8	3	3	−2	5
18	47	42	5	41	37	4	37	31	6	25	21	4	32	28	4	0	−4	4
19	52	46	6	55	53	2	34	28	6	17	13	4	34	30	4	1	−3	2
20	50	47	3	53	51	2	34	33	1	7	13		35	31	4	15	10	5
21	47	40	7	53	50	3	46	41	5	13	7	6	−4	−5	1	11	10	1
22	48	44	4	54	52	2	37	32	5	30	23	4	−4	−6	2	3	−2	5
23	49	44	5	51	45	6	49	45	4	35	41	4	8	6	2	0	−4	4
24	48	44	4	41	38	3	38	31	7	28	28		8	1	7	0	−2	2
25				42	41	1	34	27	7	12	10	2	5	1	4	9	5	4
26				41	39	2	34	32	2	27	23	4	13	7	6	21	18	3
27	41	36	5	48	45	3	41	37	4	31	25	6	18	14	4	27	22	5
28	47	44	3	48	51		36	29	7	33	27	6	26	21	3	28	25	3
29				49	45	4	34	34		13	9	4	15	12	3	5	18	
30				55	50	5	28	20	8	21	12	9	18	12	6	−12	−19	7
31				55	51	4				42	33	9				−7	−12	5
Sum.	738	672	70	1470	1392	89	1057	917	140	828	702	143	437	304	138	130	9	138
Mean.	49.2	44.8	3.9	47.4	44.9	3.2	35.2	35.7	5.0	26.7	22.6	5.3	14.6	10.1	4.9	4.2	0.3	4.5

TABLE III.—*Per Cent. of Saturation of the Air and Temperature of the Dew Point.*

Date.	JANUARY						FEBRUARY						MARCH					
	RELATIVE HUMIDITY			DEW POINT			RELATIVE HUMIDITY			DEW POINT			RELATIVE HUMIDITY			DEW POINT		
	7 a. m.	7 p. m.	Mean.	7 a. m.	7 p. m.	Mean.	7 a. m.	7 p. m.	Mean.	7 a m.	7 p.m.	Mean.	7 a m.	7 p.m.	Mean.	7 a m.	7p. m.	Mean.
1	68	65	66.5	**—18**	1	—8.5	86	**100**	93.	6	21	13.5	90	59	74.5	23	14	18.5
2	49	**41**	45.	10	14	12.	86	62	74.	5	11	8.	89	78	83.5	21	20	20.5
3	38	66	52.	11	14	12.5	55	63	59.	12	21	16.5	76	40	58.	16	14	15.
4	88	92	90.	9	18	13.5	57	48	52.5	6	4	5.	89	53	71.	27	20	23.5
5	78	65	71.5	15	23	19.	45	32	38.5	9	16	12.5	84	75	79.5	27	23	25.
6	77	73	75.	15	23	19.	51	32	41.5	18	13	15.5	60	49	54.5	15	17	16.
7	55	71	63.	17	20	18.5	77	57	67.	17	20	18.5	20	34	27.	1	18	9.5
8	68	80	74.	17	19	18.	77	69	73	20	20	20.	51	71	61.	18	8	13.
9	75	60	67.5	8	17	12.5	**100**	77	88.5	24	15	19.5	43	**100**	71.5	10	**28**	19.
10	57	81	69.	10	20	15.	84	55	60.5	1	12	6.5	92	**100**	96.	18	22	20.
11	56	65	60.5	—3	1	—1.	62	77	69.5	—1	15	7.	86	75	80.5	5	15	10.
12	80	62	71.	1	2	1.5	56	73	64.5	12	23	17.5	87	60	73.5	15	17	16.
13	46	52	49.	—5	1	—2.	65	50	57.5	5	17	11.	63	62	62.5	21	26	23.5
14	86	80	83.	5	1	3.	72	76	74.	26	**29**	27.5	**100**	70	85.	17	10	13.5
15	64	71	67.5	0	11	5.5	58	40	49.	22	17	19.5	48	76	62.	4	14	9.
16	87	57	72.	7	6	6.5	51	52	51.5	15	21	18.	71	59	65.	8	14	11.
17	75	70	72.5	2	7	4.5	64	32	48.	0	—7	—3.5	60	47	53.5	15	19	17.
18	66	83	74.5	10	6	8.	83	36	59.5	6	—1	2.5	42	68	55.	14	11	12.5
19	54	71	62.5	3	11	7.	92	86	89.	18	12	15.	62	34	48.	8	1	4.5
20	83	83	83.	0	7	3.5	78	50	64.	16	17	16.5	57	48	52.5	12	11	11.5
21	75	83	79.	—4	1	—2.5	77	41	59.	15	14	14.5	60	83	71.5	15	0	7.5
22	65	61	63	5	10	7.5	93	71	82.	20	11	15.5	**100**	63	81.5	—6	—**15**	10.5
23	68	**100**	84.	4	17	10.5	64	**30**	47.	0	4	2.	61	50	55.5	—3	0	3.
24	84	**100**	92.	1	2	1.5	76	38	57.	10	17	13.5	67	38	52.5	19	15	17.
25	76	76	76.	—10	—10	—10.	**30**	48	39.	11	21	16.	**20**	24	22.	3	10	6.5
26	74	52	63.	—9	—1	—5.	80	56	68.	19	20	19.5	24	72	48.	4	12	8.
27	46	43	44.5	2	10	6.	78	61	69.5	21	19	20.	81	40	60.5	5	1	3.
28	84	75	79.5	1	13	7.	42	62	52	14	26	20.	48	66	57.	4	14	9.
29	91	59	75.	**24**	14	19.							84	**100**	92.	10	22	16.
30	73	61	67.	14	11	12.5							75	68	71.5	13	17	15.
31	60	77	68.5	0	15	12.							79	90	84.5	20	23	21.5
Sum.	2146	2175	2160.5	151	302	226.5	1939	1574	1756.5	347	428	387.5	2069	1952	2010.5	379	430	404.5

Date.	APRIL						MAY						JUNE					
	RELATIVE HUMIDITY			DEW POINT			RELATIVE HUMIDITY			DEW POINT			RELATIVE HUMIDITY			DEW POINT		
	7 a. m.	7 p. m.	Mean.	7 a. m.	7 p. m.	Mean.	7 a. m	7 p. m.	Mean.	7 a. m.	7 p. m.	Mean.	7 a. m.	7 p. m.	Mean.	7 a. m.	7 p. m.	Mean.
1	87	60	73.5	15	17	16.	94	90	92.	24	24	24.	32	30	31.	31	34	32.5
2	34	36	35.	15	22	18.5	88	84	86.	25	26	25.5	30	18	24.	32	25	28.5
3	53	100	76.5	22	22	22.	68	70	69.	20	20	20.	67	93	80.	38	45	41.5
4	44	93	68.5	9	20	14.5	100	100	100.	25	30	27.5	100	70	85.	37	34	35.5
5	87	74	80.5	15	14	14.5	84	68	76.	26	23	24.5	85	55	70.	39	35	37.
6	93	47	70.	19	19	19.	75	68	71.5	26	29	27.5	79	75	77.	40	44	42.
7	100	86	93.	31	30	30.5	63	81	72.	32	37	34.5	66	68	67.	37	41	39.
8	85	45	65.	29	22	25.5	100	88	94.	36	35	35.5	51	69	60.	34	42	38.
9	54	50	52.	24	24	24.	87	37	62.	34	25	29.5	53	69	61.	37	42	39.5
10	42	40	41.	23	26	24.5	53	25	39.	31	22	26.5	81	100	90.5	45	47	46.
11	57	100	78.5	28	36	32.	40	82	61.	30	40	35.	81	80	80.5	47	44	45.5
12	100	48	74.	32	21	26.5	85	83	84.	42	42	42.	70	70	70.	44	45	44.5
13	67	34	50.5	28	23	25.5	27	76	51.5	18	40	29.	81	52	66.5	47	42	44.5
14	38	42	40.	23	33	28.	82	82	82.	40	40	40.	71	47	59.	47	39	43.
15	68	27	47.5	24	21	22.5	76	89	82.5	41	44	42.5	52	37	44.5	41	43	42.
16	51	48	49.5	28	29	28.5	75	96	85.5	38	40	39.	41	46	43.5	38	47	42.5
17	79	88	83.5	32	37	34.5	68	100	84.	30	38	34.	40	37	38.5	41	43	42.
18	91	31	61.	32	17	24.5	68	74	71.	34	36	35.	54	44	49.	46	47	46.5
19	86	58	72.	32	29	30.5	75	100	87.5	37	40	38.5	53	54	53.5	49	46	47.5
20	48	49	48.5	29	31	30.	50	57	53.5	22	35	28.5	36	51	43.5	39	46	42.5
21	66	100	83.	37	33	35.	53	46	49.5	25	30	27.5	41	30	35.5	38	41	39.5
22	68	56	62.	33	29	31.	47	32	39.5	33	35	34.	49	57	53.	48	50	49.
23	54	50	52.	26	23	24.5	22	29	25.5	20	33	26.5	51	47	49.	45	43	44.
24	69	36	52.5	29	22	25.5	95	100	97.5	46	45	45.5	47	28	37.5	43	37	40.
25	63	19	41.	31	18	24.5	83	66	74.5	42	41	41.5	26	22	24.	32	32	32.
26	23	16	22.5	25	17	21.	96	83	80.5	45	42	43.5	38	18	28.	34	27	30.5
27	57	38	47.5	26	15	20.5	83	77	80.	44	44	44.	28	22	25.	29	35	32.
28	34	18	26.	15	11	13.	58	48	53.	34	29	31.5	33	18	25.5	40	30	35.
29	72	100	86.	37	35	36.	47	29	38.	28	26	27.	32	37	34.5	33	41	37.
30	100	100	100.	34	32	33.	48	54	51.	38	36	37.	34	35	34.5	44	47	45.5
31							51	40	45.5	28	30	29.						
Sum.	1976	1689	1832.5	783	734	758.5	1129	1154	1141.5	994	1057	1025.5	1602	1479	1540.5	1195	1214	1204.5
Mean.	67.9	56.3	61.1	62 1	24.3	25.2	36.4	37.2	33.8	32.1	34.1	33.1	53.4	49.3	51.4	39.7	40.5	40.1

TABLE III.—*Per Cent. of Saturation of the Air and Temperature of the Dew Point.*

Date.	JULY						AUGUST						SEPTEMBER					
	RELATIVE HUMIDITY			DEW POINT.			RELATIVE HUMIDITY			DEW POINT			RELATIVE HUMIDITY			DEW POINT.		
	7 a. m.	7 p. m.	Mean.	7 a. m.	7 p. m.	Mean	7 a. m	7 p. m.	Mean.	7 a. m	7 p. m.	Mean.	7 a. m	7 p. m.	Mean	7 a. m.	7 p. m.	Mean.
1	76	49	62.5	47	42	44.5	63	76	69.5	40	46	43.	68	59	63.5	**51**	**48**	49.5
2	68	34	51.	41	32	33.5	**87**	37	62.	46	38	42.	58	47	52.5	47	39	43.
3	55	59	57.	41	48	44.5	44	**23**	33.5	41	34	37.5	43	23	33.	32	23	27.5
4	49	28	38.5	42	40	41.	**23**	60	44.5	35	49	42.	42	**13**	27.5	30	14	22.
5	34	39	36.5	39	43	41.	78	**100**	89.	52	49	50.5	34	75	54.5	28	32	30.
6	53	39	46.	48	43	45.5	73	76	74.5	41	47	44.	91	20	55.5	32	14	23.
7	49	36	42.5	47	45	46.	87	58	72.5	49	46	47.5	37	28	32.5	24	21	22.5
8	57	73	65.	50	52	51.	81	56	68.5	47	47	47.	44	25	34.5	25	23	24.
9	57	52	54.5	50	51	50.5	58	34	46.	46	36	41.	82	**82**	82.	32	30	31.
10	75	52	63.5	**58**	53	55.5	51	62	56.5	39	46	42.5	85	81	83.	40	29	34.5
11	79	62	70.5	56	53	54.5	65	38	51.5	44	39	41.5	80	75	77.5	28	32	30.
12	70	66	68.	55	**54**	54.5	61	38	49.5	43	43	43.	90	32	61.	30	18	24.
13	62	52	57.	53	53	53.	63	42	52.5	48	46	47.	68	24	46	30	19	24.5
14	**84**	56	70.	57	**54**	55.5	60	31	45.5	48	36	42	30	61	45.5	23	43	33.
15	73	53	63.	52	48	50.	48	33	40.5	44	39	41.5	30	19	24.5	23	24	23.5
16	82	43	62.5	51	46	48.5	72	73	72.5	50	51	50.5	**92**	54	73.	41	33	37.
17	36	34	35.	42	40	41.	62	40	51.	46	40	43.	54	23	38.5	33	25	29.
18	31	16	23.5	34	26	30.	65	24	44.5	44	35	39.5	42	23	32.5	31	25	28.
19	**19**	24	21.5	**22**	31	26.5	72	45	58.5	49	47	48.	51	**13**	32.	29	17	23.
20	26	34	30.	26	38	32.	49	42	45.5	45	48	46.5	**19**	24	21.5	20	27	23.5
21	38	21	29.5	39	32	35.5	56	65	60.5	47	53	50.	27	24	25.5	23	23	23.
22	35	24	29.5	36	37	36.5	82	37	59.9	51	41	46.	21	19	20.	16	22	19.
23	37	64	50.5	41	51	46.	73	56	64.5	51	47	49.	27	33	30.	24	29	26.5
24	48	43	45.5	44	46	45.	75	35	55.	45	39	42.	52	27	39.5	30	28	29.
25	60	40	50.	49	49	49.	61	27	44.	43	28	35.5	37	21	29.	24	20	22.
26	68	**13**	40.5	49	26	37.5	45	24	34.5	**35**	**31**	33.	50	26	38.	27	28	27.5
27	36	15	25.5	38	**25**	31.5	47	**100**	73.5	42	55	48.5	30	27	28.5	27	24	25.5
28	44	15	29.5	47	**25**	36.	73	58	65.5	**52**	51	51.5	59	30	44.5	33	29	31.
29	61	48	54.5	52	44	48.	69	36	52.5	51	43	47.	52	20	36.	24	**11**	17.5
30	62	**75**	68.5	46	45	45.5	38	61	49.5	43	52	47.5	24	41	32.5	19	38	28.5
31	81	67	74.	45	48	46.5	73	**100**	86.5	**52**	**57**	54.5						
Sum.	1705	1326	1515.5	1307	1320	1358.5	1960	1587	1773.5	1409	1359	1384.0	1510	1030	1294.0	876	788	832.0

Date							RELATIVE HUMIDITY			DEW POINT			RELATIVE HUMIDITY			DEW POINT		
	7 a. m.	7 p. m.	Mean.	7 a. m.	7 p. m.	Mean.	7 a. m.	7 p. m.	Mean.	7 a. m.	7 p. m.	Mean.	7 a. m.	7 p. m.	Mean	7 a. m.	7 p. m	Mean.
1							80	89	84.5	28	29	28.5	71	61	66.	14	14	14.
2							67	37	52.	21	12	16.5	71	81	76.	14	10	12.
3							38	**20**	28.	15	11	13.	**100**	67	83.5	4	—7	—1.5
4							52	62	57.	23	30	26.5	51	53	52.	4	14	9.
5							80	28	54.	28	10	19.	33	**100**	66.5	6	8	7.
6							**32**	26	29.	17	16	16.5	70	60	65.	—5	2	—1.5
7							37	**100**	68.5	24	20	22.	66	81	73.5	8	9	8.5
8							82	**100**	91.	11	0	5.5	64	54	59.	—10	—**18**	—14.
9							67	78	72.5	—7	5	—1.	**100**	54	77.	—**21**	—**18**	—19.5
10							85	**100**	92.5	16	30	23.	**100**	60	80.	—10	—13	—11.5
11							74	81	77.5	—1	10	4.5	56	55	55.5	—16	—3	—9.5
12							64	81	72.5	—**10**	10	0.	47	**100**	73.5	1	0	.5
13							**100**	75	87.5	3	**0**	1.5	78	**40**	59.	5	8	6.5
14							78	56	67.	5	8	6.5	47	68	56.5	—1	8	3.5
15							48	40	44.	8	17	12.5	70	64	67.	—5	7	1.
16							69	**100**	84.5	11	19	15.	64	48	56.	7	9	8.
17							74	90	82.	19	**31**	25.	**17**	64	40.5	4	7	5.5
18	54	79	66.5	22	27	24.5	82	66	74.	**31**	27	29.	71	84	77.5	—4	16	6.
19	**100**	85	92.5	24	16	20.	54	45	49.5	22	22	22.	82	88	85.	11	**25**	18.
20	57	61	59.	**9**	14	11.5	68	**100**	83.	27	2	14.5	51	77	64.	12	22	17.
21	61	36	48.5	14	**10**	12.	**100**	76	88.	—2	1	—.5	**100**	76	88.	13	2	7.5
22	57	43	50.	24	28	26.	51	66	58.5	3	8	5 5	57	**100**	78 5	—1	13	6.
23	39	54	46.5	23	26	24.5	81	57	69.	9	9	9.	**100**	74	87.	3	—1	1.
24	**100**	**100**	100.	**27**	21	24.	79	83	81.	6	13	9.5	58	78	68.	0	5	2 5
25	**19**	50	34.5	12	17	14.5	63	45	54.	4	6	5.	58	58	58.	11	11	11.
26	38	20	29.	16	11	13.5	79	75	77.	6	20	13.	78	68	73.	21	23	22.
27	45	38	41.5	18	19	18.5	73	56	64.5	16	17	16.5	88	69	78.5	**25**	24	24.5
28	34	88	61.	15	25	20.	88	72	80.	25	15	20.	66	48	57.	21	21	21.
29	83	**100**	91.5	13	**29**	21.	72	**100**	86.	15	28	21.5	**100**	**100**	100.	18	4	11.
30	28	24	26.	10	19	14.5	69	72	70.5	11	15	13.	**100**	**100**	100.	10	2	6.
31	24	**16**	20.	15	11	13.							**100**	74	87.	—5	—1	—3.
Sum.	739	794	766 5	242	273	257.5	2082	2076	2079	384	441	412.5	2214	2202	2208	134	203	168.5
Mean	52.8	56.7	54.7	17.3	19 5	18.4	69.4	69.2	69.3	12.8	14.7	13.7	71.4	71.	71.2	4.3	6.5	5.4

TABLE IV. *Weekly Means of Soil Temperatures.*

WEEK ENDING.	AIR TEMP	DEPTH				
		3 INCHES	6 INCHSS	12 INCHES	24 INCHES	36 INCHES
January 7	22.2	22.7	24.3	26.4	29.1	32.0
January 14	15.1	20.0	22.8	27.0	29.1	31.8
January 21	10.1	15.8	19.0	22.6	25.8	29.6
January 28	10.0	13.9	16 2	20.3	23.9	27.8
February 4	10.1	23.1	23.5	24.4	25.4	27.3
February 11	24.9	27.1	27.8	27.7	28.1	29.4
February 18	26.2	27.6	28.5	28 7	29.2	30.3
February 25	25.0	26.6	28.0	28.4	29.8	31 0
March 4	28.6	33.3	33.9	32 4	31.8	32.0
March 11	26.6	32.4	33.1	33.0	33.2	33.8
March 18	24.5	30.4	32.1	32 2	32.8	34.0
March 25	19.9	28.9	30.8	31.1	32.3	33.8
April 1	21.5	30.9	32.9	32.6	32 6	33.6
April 8	30.3	35.7	36.0	35.4	34.9	34.8
April 15	42.4	45.4	44.9	41.6	39.6	38 3
April 22	42.9	46.1	47.0	46.9	44.5	41.9
April 29	44.2	48.1	49.9	47.2	45.4	43.1
May 6	29.9	38.6	40.4	42.1	42.9	43 5
May 13	45.8	48.4	49.4	48.6	45 8	43.6
May 20	43.6	44.4	45.7	47.3	46.9	45.1
May 27	51.2	51.1	51.2	51.0	48.7	47 1
June 3	53.7	56.6	57.4	55.9	52.9	49.7
June 10	47.4	55.9	56.7	56.7	55.1	52.3
June 17	58.1	58.9	59.6	58.5	56.1	53 9
June 24	64.5	66.6	67.6	. .	61.6	57.9
July 1	65.5	69.6	71.0	69.1	64.9	60.9
July 8	62.9	69.1	70 5	70.1	66.1	62.7
July 15	65.4	70.4	72.3	71.0	66 9	63.8
July 22	65.1	69.7	71.1	70.8	66.9	64.3
July 29	67.0	69.9	71.9	71.2	67.1	64 4
August 5	57.8	66.6	70.8	69.1	67.3	65 1
August 12	51.1	64.3	67.5	67.4	64.9	63.5
August 19	62.8	69.2	71.5	70.6	66.4	64.2
August 26	61.7	67.8	71.1	70 6	66.9	65 0
September 2	62.3	66.3	67.5	68.8	66.9	63.5
September 9	46.6	56.0	61.6	63.6	63.0	62.6
September 16	43.9	66.0	59.2	59.6	58.1	58 3
September 23	55.1	58.7	60.7	60.9	58.4	57.9
September 30	50.6	54.4	58.2	59.6	58.4	58.0
October 7	37.7	44.2	49.7	52.4	54.1	55.
October 14	42.2	44.9	48.6	50.7	50.9	52.4
October 21	25.1	35.8	40.7	45.9	48.2	49.1
October 28	33.8	35.0	36.9	40.0	41.9	45.1
November 4	31.6	30.2	38.5	40.6	41.2	45 4
November 11	20.3	31.6	33.9	38.7	40.6	42.8
November 18	19 5	25.7	27.4	32.5	25.3	39.3
November 25	16.6	25.9	27.7	31.6	34.2	37 8
December 2	21.1	24.4	25.3	28.9	31.7	35.3
December 9	5.1	15.3	19.1	23.2	28.8	33.1
December 16	7.6	11.3	14.4	19.1	24.1	29
December 23	13.1	16.7	18.3	21.9	24.4	28.0
December 30	18.1	20.8	20.9	23.3	24 9	27.
Sums	1928.3	2198.3	2305.0	2289.2	2330.0	2353.
Means	37.1	42.3	44.3	44.0	44.8	45

	7 a. m.	7 p. m.	Mean.	7 a. m.	7 p. m.	Mean.	7 a. m.	7 p. m.	Mean.	7 a. m.	7 p. m.	Mean.
1	**23.324**	**23.250**	23.287	23.107	23.157	23.132	23.031	23.115	23.073	23.172	23.204	23.188
2	23.214	23.086	23.150	**23.243**	23.157	23.200	**23.143**	**23.145**	23.147	22.984	22.770	22.877
3	23.024	23.071	23.047	23.015	22.843	22.929	23.033	22.947	22.990	22.670	23.092	22.881
4	23.068	23.027	23.047	22.935	23.156	23.045	22.917	22.917	22.917	**22.180**	23.119	23.149
5	22.999	23.039	23.019	23.121	23.017	23.069	22.875	22.989	22.932	23.108	23.105	23.106
6	22.961	22.673	22.817	22.925	22.911	22.918	23.073	23.081	23.077	23.015	22.861	22.938
7	22.675	22.801	22.738	22.931	22.863	22.897	23.071	22.975	23.023	22.862	22.953	22.907
8	22.789	22.731	22.760	22.833	22.933	22.883	22.869	22.837	22.853	23.035	23.083	23.059
9	22.744	22.754	22.749	23.033	23.049	23.041	22.731	22.731	22.731	23.163	23.183	23.173
10	22.622	22.729	22.675	22.997	22.989	22.993	22.685	22.725	22.705	23.101	23.021	23.061
11	22.668	22.623	22.645	23.057	23.119	23.088	22.749	22.715	22.732	23.019	23.115	23.067
12	22.777	22.867	22.822	23.061	23.087	23.074	22.749	22.689	22.719	**23.272**	**23.265**	23.268
13	22.870	22.821	22.845	23.218	23.044	23.131	22.564	**22.472**	22.518	23.229	23.121	23.175
14	22.907	22.945	22.926	22.897	22.991	22.944	**22.374**	22.548	22.461	23.125	23.039	23.082
15	22.984	23.032	23.008	22.981	22.887	22.934	22.559	22.737	22.648	23.051	22.945	22.998
16	22.884	22.842	22.863	**22.665**	**22.556**	22.611	22.861	22.897	22.879	22.891	22.829	22.860
17	22.828	22.839	22.833	22.763	22.769	22.766	22.927	22.767	22.847	22.935	22.915	22.925
18	22.942	22.951	22.946	22.743	22.763	22.753	22.667	22.763	22.715	22.993	23.001	22.997
19	22.813	22.781	22.797	22.803	23.082	22.942	22.923	22.809	22.866	23.131	23.085	23.108
20	22.801	22.877	22.839	23.100	23.094	23.097	22.829	22.784	22.806	23.015	22.871	22.943
21	22.905	22.847	22.876	22.942	22.875	22.908	22.673	22.600	22.637	22.771	23.011	22.891
22	22.712	22.710	22.711	23.049	22.994	23.022	22.806	22.907	22.855	23.039	23.093	23.066
23	22.620	**22.567**	22.593	23.051	23.045	23.048	22.959	22.939	22.949	23.095	23.135	23.115
24	**22.603**	22.707	22.657	23.019	22.961	22.990	22.913	22.789	22.851	23.249	23.231	23.240
25	22.873	22.964	22.918	22.897	22.997	22.947	22.685	22.660	22.673	23.249	23.219	23.234
26	22.976	22.951	22.963	23.061	23.123	23.092	22.663	22.767	22.715	23.159	22.977	23.069
27	23.025	22.967	22.996	23.209	23.169	23.189	22.881	22.848	22.864	23.057	23.081	23.069
28	23.073	23.059	23.066	23.023	23.015	23.019	22.854	22.983	22.918	23.007	22.637	22.822
29	22.835	22.931	22.883				23.051	23.106	23.079	22.629	**22.601**	22.615
30	23.034	23.080	23.057				23.048	22.962	23.005	22.741	22.907	22.824
31	23.103	23.204	23.153				22.940	23.006	22.973			
Sum.	709.658	709.726	709.692	643.679	643.645	643.662	708.109	708.210	708.159	690.945	690.469	690.707
Mean.	22.892	22.927	22.893	22.988	22.987	22.988	22.842	22.844	22.843	23.031	23.015	23.023

TABLE V. (Continued).—*Atmospheric Pressure.*

Date.	MAY			JUNE			JULY			AUGUST		
	7 a. m.	7 p. m.	Mean.	7 a. m.	7 p. m.	Mean.	7 a. m.	7 p. m.	Mean.	7 a. m.	7 p. m.	Mean
1	22.934	22.966	22.950	23.024	22.881	22.953	22.967	22.945	22.956	23.063	23.085	23.074
2	22.935	22.934	22.934	**22.880**	**22.765**	22.822	23.176	23.239	23.207	23.131	23.069	23.100
3	22.992	23.084	23.038	22.980	23.111	23.046	23.230	23.199	23.215	23.121	**22.930**	23.025
4	23.024	22.973	22.999	23.223	**23.277**	23.250	23.230	23.103	23.166	23.055	23.089	23.072
5	23.059	**23.215**	23.137	**23.253**	23.173	23.213	23.097	23.059	23.078	23.173	23.139	23.156
6	**23.255**	23.113	23.184	23.164	23.115	23.140	23.154	23.147	23.151	23.151	23.195	23.173
7	23.009	22.965	22.987	23.153	23.137	23.145	23.210	23.185	23.198	23.283	**23.295**	23.289
8	23.077	23.079	23.078	23.193	23.127	23.160	23.269	23.227	23.248	23.283	23.197	23.240
9	23.159	23.133	23.146	23.099	23.007	23.053	23.256	23.229	23.243	23.281	23.247	23.264
10	23.191	23.107	23.149	22.984	22.955	22.969	23.230	23.171	23.200	23.275	23.263	23.269
11	23.063	23.043	23.053	22.979	22.997	22.988	23.232	23.233	23.233	**23.285**	23.249	23.267
12	23.009	22.983	22.993	23.006	23.057	23.032	23.239	23.207	23.223	23.265	23.201	23.233
13	22.937	22.913	22.925	23.124	23.047	23.085	23.230	23.175	23.202	23.225	23.187	23.206
14	22.909	22.860	22.889	23.156	23.121	23.139	23.194	23.143	23.169	23.169	23.181	23.175
15	22.877	22.921	22.899	23.158	23.139	23.148	23.150	23.137	23.143	23.201	23.149	23.175
16	22.955	22.845	22.900	23.130	23.155	23.143	23.084	22.965	23.025	23.215	23.171	23.193
17	22.809	**22.707**	22.758	23.201	23.257	23.229	**22.964**	22.957	22.960	23.181	23.139	23.160
18	22.751	22.763	22.757	23.234	23.223	23.229	23.025	**22.927**	22.976	23.179	23.093	23.136
19	**22.725**	22.709	22.717	23.164	23.059	23.111	23.058	23.087	23.072	23.187	23.193	23.190
20	22.779	22.917	22.848	23.034	22.981	23.007	23.107	23.105	23.106	23.233	23.171	23.202
21	23.061	23.071	23.066	23.040	22.959	23.000	23.157	23.153	23.155	23.159	23.097	23.128
22	23.107	22.819	22.963	23.036	22.985	23.010	23.259	23.191	23.225	23.075	23.191	23.133
23	22.947	22.769	22.858	23.014	23.059	23.037	23.243	23.253	23.248	23.200	23.151	23.175
24	22.867	22.999	22.933	23.140	22.995	23.068	**23.324**	23.295	23.309	23.223	23.221	23.222
25	23.050	23.007	23.028	23.012	22.931	22.971	23.286	23.161	23.224	23.284	23.172	23.228
26	22.987	22.961	22.974	23.069	23.039	23.054	23.184	23.108	23.146	23.284	23.163	23.224
27	22.963	22.823	22.893	23.140	23.091	23.115	23.112	23.109	23.111	23.197	23.172	23.185
28	22.781	22.891	22.836	23.022	23.045	23.033	23.155	23.079	23.117	23.109	23.172	23.141
29	23.073	23.027	23.050	23.098	22.950	23.024	23.163	23.117	23.142	23.199	23.054	23.126
30	22.899	22.873	22.886	22.906	22.788	22.847	23.114	23.135	23.125	**23.047**	22.954	23.001
	[illegible]	[illegible]	[illegible]				23.279	23.083	23.181	23.055	23.029	23.042

Date.	SEPTEMBER			OCTOBER			NOVEMBER			DECEMBER		
	7 a. m.	7 p. m.	Mean.	7 a. m.	7 p. m.	Mean.	7 a. m.	7 p. m.	Mean.	7 a. m.	7 p. m.	Mean.
1	22.997	23.075	23.036	**22.624**	**22.699**	22.661	23.018	23.151	23.084	22.953	22.941	22.947
2	23.023	23.047	23.035	22.871	23.003	22.937	23.136	23.181	23.158	22.677	23.053	22.865
3	23.039	23.035	23.037	23.004	22.915	22.960	22.975	22.867	22.921	23.219	23.174	23.197
4	23.051	22.987	23.019	23.039	23.193	23.116	22.841	22.885	22.863	23.098	23.040	23.069
5	23.013	23.135	23.074	22.943	23.157	23.050	23.101	**23.200**	23.150	22.927	23.121	23.024
6	23.223	23.335	23.279	23.065	23.157	23.111	23.019	22.833	22.925	23.185	23.179	23.182
7	23.273	23.151	23.212	23.121	23.221	23.171	22.841	22.921	22.881	23.045	23.001	23.023
8	23.165	23.066	23.115	23.233	23.077	23.155	22.924	23.100	23.012	23.163	23.293	23.228
9	23.248	23.273	23.262	22.815	22.929	22.872	23.196	23.150	23.173	**23.311**	23.293	23.302
10	**23.400**	**23.408**	23.404	22.957	23.123	23.040	23.023	22.951	22.987	23.232	23.084	23.158
11	23.398	23.300	23.334	23.195	23.075	23.135	22.986	23.057	23.022	22.953	22.997	22.975
12	23.100	22.950	23.030	23.127	23.185	23.156	23.000	23.030	23.015	23.023	23.062	23.044
13	22.983	23.037	23.011	23.235	23.177	23.203	23.126	23.192	23.159	23.058	23.050	23.054
14	23.020	23.023	23.022	23.087	22.931	23.009	**23.222**	23.132	23.177	23.051	23.021	23.036
15	23.093	22.994	23.043	22.837	22.977	22.907	22.986	22.861	22.924	22.997	23.091	23.044
16	23.155	23.144	23.150	23.157	23.253	23.205	22.835	22.861	22.848	23.069	23.059	23.064
17	23.191	23.193	23.192	23.219	22.951	23.085	22.775	22.815	22.795	23.067	23.063	23.065
18	23.229	23.183	23.206	22.885	22.839	22.862	22.919	22.957	22.938	22.998	22.995	22.997
19	23.181	23.107	23.144	22.949	23.083	23.016	22.881	22.711	22.795	22.895	22.997	22.946
20	23.079	23.009	23.044	23.087	23.127	23.107	**22.470**	22.769	22.619	22.847	22.768	22.808
21	23.023	23.003	23.013	23.122	23.073	23.097	22.959	22.972	22.966	22.805	22.993	22.899
22	23.006	22.999	23.002	23.017	22.965	22.991	22.879	22.897	22.888	22.949	22.955	22.952
23	22.933	23.043	22.988	22.853	22.913	22.883	22.883	22.840	22.862	23.139	23.200	23.169
24	23.109	23.131	23.120	23.041	23.319	23.180	22.858	23.044	22.951	23.258	**23.298**	23.278
25	23.241	23.253	23.247	**23.383**	23.315	23.349	23.062	23.148	23.105	23.176	23.106	23.142
26	23.292	23.177	23.234	23.209	22.963	23.086	23.094	22.848	22.971	23.135	23.178	23.157
27	23.105	22.933	23.019	23.009	23.013	23.011	22.966	22.792	22.879	23.124	23.134	23.129
28	22.999	22.879	22.939	22.927	23.151	23.039	22.685	22.846	22.766	22.908	**22.710**	22.809
29	22.945	23.005	22.975	23.275	**23.327**	23.301	22.819	**22.627**	22.723	**22.652**	22.815	22.734
30	**22.915**	**22.707**	22.811	23.293	23.121	23.207	22.823	22.912	22.867	22.917	22.955	22.936
31				22.981	22.887	22.934				23.053	23.071	23.062
Sum.	693.402	692.592	692.998	714.620	715.119	714.369	688.312	688.550	688.431	713.898	714.683	714.290
Mean.	23.113	23.086	23.099	23.052	23.067	23.060	22.943	22.951	22.947	23.029	23.054	23.041

TABLE VI.—*Wind.*

JANUARY.

Date.	DIRECTION FROM.			Daily distance in miles.	Greatest number of mi. in any one hour of day.	Maximum velocity in miles per hour.
	7 a.m.	Noon.	7 p.m.			
1	n	ne	se	73	9	16
2	s	s	se	167	11	17
3	s	nw	n	324	22	26
4	n	n	se	206	20	28
5	s	se	sw	152	11	16
6	se	s	s	353	**30**	**37**
7	sw	s	s	348	20	36
8	s	s	s	312	19	28
9	e	sw	e	252	21	24
10	s	sw	s	431	**30**	36
11	se	n	ne	263	21	28
12	n	ne	e	242	16	18
13	se	sw	ne	173	11	16
14	n	n	ne	218	19	21
15	s	sw	nw	152	16	17
16	se	sw	n	173	28	30
17	n	n	ne	264	20	24
18	s	sw	s	195	12	24
19	sw	sw	nw	223	22	25
20	se	ne	nw	288	22	26
21	se	ne	se	132	13	14
22	w	n	w	162	15	20
23	sw	n	ne	264	18	28
24	ne	n	nw	240	20	21
25	ne	sw	n	212	13	17
26	s	sw	sw	148	15	19
27	sw	s	sw	**527**	24	36
28	sw	s	s	410	24	33
29	sw	w	nw	203	17	21
30	sw	s	sw	353	26	36
31	sw	n	n	362	19	28
Sum.				7812		
Daily mean				252		
Hourly mean				10.5		

FEBRUARY.

Date.	DIRECTION FROM.			Daily distance in miles.	Greatest number of mi. in any one hour of day.
	7 a.m.	Noon.	7 p.m.		
1	se	n	ne	236	20
2	se	se	sw	218	22
3	sw	sw	w	226	26
4	nw	n	w	438	19
5	sw	w	sw	500	25
6	sw	sw	sw	441	22
7	s	sw	s	356	20
8	sw	sw	n	309	19
9	nw	nw	e	283	26
10	n	n	n	156	9
11	e	s	e	237	24
12	sw	sw	w	247	19
13	se	s	sw	346	19
14	nw	w	nw	536	**33**
15	w	sw	nw	**548**	27
16	sw	sw	sw	414	29
17	ne	nw	e	494	35
18	s	n	w	302	22
19	w	nw	nw	343	21
20	s	sw	sw	318	28
21	ne	sw	sw	192	14
22	n	w	ne	273	26
23	se	n	nw	274	22
24	se	sw	sw	208	15
25	sw	w	w	296	22
26	se	nw	ne	265	21
27	ne	w	e	191	15
28	sw	nw	nw	162	14
Sum.				8809	
Daily mean				314.6	
Hourly mean				13.1	

TABLE VI. (Continued).—*Wind.*

MARCH.

IRECTION FROM.			Daily distance in miles.	Greatest number of mi. in any one hour of day.	Maximum velocity in miles per hour.
m.	Noon.	7 p.m.			
e	n	ne	363	23	29
w	n	n	284	26	28
e	sw	n	255	21	27
s	sw	sw	182	18	24
s	sw	n	264	15	22
w	sw	s	302	20	25
e	sw	sw	309	24	25
w	sw	ne	425	28	29
w	w	ne	533	39	49
e	sw	s	380	24	26
n	sw	sw	182	16	17
n	nw	s	242	21	26
w	sw	sw	318	22	25
n	nw	nw	426	36	41
w	sw	w	533	29	37
e	sw	e	407	34	39
s	s	se	**622**	**48**	**54**
w	sw	sw	387	36	41
w	sw	sw	528	40	43
w	sw	s	518	34	36
w	s	ne	368	24	33
e	ne	e	502	38	43
w	sw	sw	287	27	29
e	s	sw	510	30	33
w	sw	sw	418	28	34
w	sw	e	525	36	50
e	w	sw	495	38	40
w	sw	n			
e	s	se	136	12	16
e	sw	sw	151	14	18
s	n	sw	266	19	23
. . . .			11118		
an.			370.6		
ean.			15.4		

APRIL.

Date.	DIRECTION FROM.			Daily distance in miles.	Greatest number of mi. in any one hour of day.	Maximum velocity in miles per hour.
	7 a.m.	Noon.	7 p.m.			
1	sw	n	sw	261	24	27
2	s	sw	sw	215	20	24
3	ne	n	n	303	22	32
4	sw	n	ne	433	34	40
5	s	n	se	183	15	18
6	s	s	s	282	18	24
7	sw	w	w	348	24	29
8	w	w	nw	411	32	**41**
9	w	n	sw	429	37	40
10	s	s	se	261	24	28
11	sw	n	n	217	18	24
12	nw	nw	n	226	21	23
13	s	nw	s	387	**38**	41
14	e	nw	w	256	23	25
15	s	s	se	232	19	20
16	s	s	ne	117	12	13
17	n	s	s	347	34	39
18	se	w	nw	97	11	13
19	n	n	se	305	30	36
20	s	nw	s	380	28	30
21	n	n	n	306	25	34
22	w	nw	w	326	29	32
23	s	n	n	249	18	24
24	s	n	n	306	30	35
25	s	n	n	213	20	24
26	s	sw	sw	272	29	24
27	n	nw	n	**471**	22	35
28	s	s	se	400	30	36
29	s	n	n	261	22	26
30	nw	n	ne	248	20	24
Sum.				8742		
Daily mean.				291.4		
Hourly mean.				12.1		

TABLE VI. (Continued).—*Wind.*

MAY.

Date.	DIRECTION FROM. 7 a.m.	Noon.	7 p.m.	Daily distance in miles.	Greatest number of mi. in any one hour of day.	Maximum velocity in miles per hour.
1	ne	n	ne	320	24	32
2	s	s	e			
3	se	s	e	459	20	32
4	se	se	e	605	35	40
5	w	e	se	408	24	[illegible]
6	s	s	se	248	20	24
7	s	sw	ne	258	21	23
8	n	nw	se	230	28	37
9	s	s	n			
10	sw	w	w	211	19	21
11	n	nw	e	271	18	20
12	e	ne	n	316	25	32
13	s	s	n	119	18	20
14	s	e	e	159	25	36
15	s	s	se	344	30	33
16	se	se	sw	366	37	41
17	sw	s	sw	522	50	55
18	sw	sw	s	404	21	28
19	s	se	s	244	20	24
20	nw	sw	nw	248	25	39
21	w	sw	sw	455	35	38
22	sw	sw	sw	274	18	21
23	nw	s	s	282	16	20
24	se	se	ne	552	43	53
25	s	sw	w	315	33	36
26	nw	n	nw	219	20	24
27	s	s	s	339	25	30
28	s	sw	w	400	32	38
29	nw	e	se			
30	s	s	sw			
31	w	sw	w	333	25	26
Sum				8922		
Daily mean				330.4		
Hourly mean				13.7		

JUNE.

Date.	DIRECTION FROM 7 a.m.	Noon	7 p.m.	Daily distance in miles.	Greatest number of mi. in any one hour of day.
1	sw	sw	w	321	24
2	se	s	s	416	26
3	e	sw	sw	401	37
4	se	n	ne	232	24
5	nw	nw	nw	186	19
6	sw	nw	ne	142	13
7	sw	ne	se	171	14
8	s	nw	e	263	22
9	e	e	se	247	21
10	e	se	se	203	20
11	s	n	n	282	28
12	sw	se	ne	209	24
13					
14	se	w	ne	220	18
15	s	se	s	236	21
16	w	nw	e	220	15
17	s	nw	sw	162	13
18	sw	n	e	214	19
19	sw	se	se	252	19
20	s	se	s	317	32
21	s	sw	e	221	22
22	s	sw	se	248	23
23	se	sw	sw	238	25
24	sw	sw	sw	351	24
25	sw	w	w	445	30
26	sw	w	w	455	32
27	s	w	n	287	20
28	sw	nw	sw	210	13
29	n	w	nw	306	21
30	sw	nw	se	436	35
Sum				7890	
Daily mean				272.4	
Hourly mean				11.3	

TABLE VI. (Continued).—*Wind.*

JULY.

RECTION FROM.			Daily distance in miles.	Greatest number of mi. in any one hour of day.	Maximum velocity in miles per hour.
n.	Noon.	7 p.m			
n	o	n	401	28	31
n	n	ne	252	22	26
s	se	se	254	17	20
s	o	s	321	23	25
v	w	sw	191	12	16
s	o	s	214	18	19
s	w	s	137	19	24
s	e	se	153	14	23
s	se	e	375	32	35
s	e	e	213	24	27
n	ne	se	230	21	24
v	e	s	220	20	22
v	e	e			
s	ne	s			
s	se	s			
s	s	s			
v	w	w			
v	w	sw	130	15	18
v	o	o	421	28	32
e	se	s	**543**	**40**	43
s	w	sw	197	18	26
e	sw	sw	198	18	20
v	se	sw	188	15	17
n	s	s	136	13	24
v	se	s	142	22	25
s	w	nw	154	16	18
o	w	nw	287	25	27
e	w	nw	283	25	32
e	e	s	200	20	22
o	ne	n	120	21	25
s	s	s	299	35	**53**
. . . .			6322		
an			243.1		
ean			10.1		

AUGUST.

Date.	DIRECTION FROM.			Daily distance in miles.	Greatest number of mi. in any one hour of day.	Maximum velocity in miles per hour.
	7 a.m.	Noon.	7 p.m.			
1	s	sw	n	198	19	21
2	s	sw	o	183	23	25
3	o	sw	o	144	17	18
4	s	se	n			
5	n	ne	n	153	17	27
6	n	sw	o	141	14	24
7	o	sw	o	58	17	34
8	o	se	ne	100	9	13
9	s	s	se	130	13	15
10	s	nw	ne	148	14	18
11	s	nw	ne	175	18	25
12	s	nw	w	116	14	16
13	s	nw	e	164	29	**36**
14	s	w	n	91	14	20
15	s	w	sw	166	19	21
16	s	s	s	189	22	25
17	s	nw	w	239	**24**	30
18	se	sw	se	212	18	26
19	se	sw	se	227	21	27
20	sw	s	s	249	19	23
21	sw	sw	se	147	21	30
22	sw	n	n	211	18	19
23	o	s	s	119	14	18
24	se	e	o	153	12	20
25	s	se	e	125	12	15
26	se	ne	s	96	14	17
27	se	sw	se	230	20	24
28	s	ne	ne	146	18	25
29	ne	se	sw	148	17	30
30	e	sw	sw	145	15	18
31	e	sw	sw	**242**	21	26
Sum.				4854		
Daily mean.				161.8		
Hourly mean.				6.7		

TABLE VI. (Continued).—*Wind.*

SEPTEMBER.

Date.	DIRECTION FROM.			Daily distance in miles.	Greatest number of mi. in any one hour of day.	Maximum velocity in miles per hour.
	7 a.m.	Noon.	7 p.m.			
1	e	s	e	177	17	20
2	sw	sw	s	182	19	24
3	sw	w	s	415	32	38
4	sw	w	se	240	22	25
5	sw	e	ne	248	24	30
6	sw	e	ne	301	32	41
7	n	n	se	226	18	20
8	n	s	n	168	19	24
9	s	n	s	438	**39**	**45**
10	n	n	n	244	23	25
11	e	s	e	227	17	23
12	s	s	ne	144	12	14
13	se	s	s	168	20	22
14	s	w	s	245	26	30
15	n	w	w	250	25	28
16	nw	s	se	346	28	31
17	nw	s	se	161	12	13
18	se	e	s	123	10	14
19	s	s	e	106	12	14
20	se	s	w	226	20	24
21	se	sw	s	167	14	17
22	w	s	s	201	17	20
23	w	w	e	268	28	33
24	w	nw	e	179	19	21
25	s	w	e	184	17	20
26	w	s	n	97	16	19
27	sw	sw	se	171	28	33
28	sw	s	s	235	28	34
29	w	w	s	**486**	29	33
30	e	se	se	302	29	34
Sum.				6935		
Daily mean.				231.2		
Hourly mean.				9.6		

OCTOBER.

Date.	DIRECTION FROM.			Daily distance in miles.	Greatest number of mi. in any one hour of day.
	7 a.m.	Noon.	7 p.m.		
1	s	sw	w	541	51
2	w	w	nw	549	**47**
3	se	se	w	**700**	**47**
4	nw	nw	nw	427	34
5	se	n	se	273	24
6	sw	sw	ne	186	15
7	se	se	e	500	29
8	sw	sw	se	136	21
9	s	s	sw	409	40
10	s	sw	sw	431	22
11	sw	sw	sw	387	23
12	w	nw	se	398	24
13	n	nw	sw	197	20
14	se	sw	se		
15	w	nw	nw	363	28
16	o	o	o	203	24
17	o	nw	w	117	30
18	sw	nw	n	254	33
19	nw	nw	nw	284	20
20	se	nw	w	322	22
21	se	w	sw	212	28
22	s	sw	o	241	21
23	sw	w	w	246	25
24	w	w	n	390	30
25	o	w	e	170	31
26	s	sw	w	229	22
27	w	w	s	385	26
28	s	nw	o	354	29
29	o	o	o	121	23
30	e	w	sw	180	16
31	se	w	w	372	33
Sum.				9577	
Daily mean.				319.2	
Hourly mean.				13.3	

TABLE VI. (Concluded) —*Wind.*

NOVEMBER

ECTION FROM		Daily distance in miles.	Greatest number of mi. in any one hour of day	Maximum velocity in miles per hour.
Noon	7 p.m.			
w	s	340	35	40
w	w	213	18	20
w	w	345	31	36
w	w	530	48	**60**
w	nw	**647**	**49**	57
sw	sw	370	32	37
nw	n	570	40	44
s	se	476	39	42
o	s			
sw	se	196	22	27
nw	s	86	28	32
n	sw	67	8	12
n	nw	90	10	18
se	s	151	10	14
sw	sw	228	20	26
nw	sw	338	35	39
sw	w	320	30	32
w	sw	560	30	45
w	sw	440	36	38
n	nw	542	40	46
nw	sw	600	36	39
w	sw	481	30	33
sw	sw	286	21	25
n	n	174	23	30
sw	ne	211	23	26
s	ne	224	28	31
nw	w	198	24	27
nw	w	476	35	39
s	s	406	25	30
w	w	347	22	26
. . . .		9912		
an		341.8		
ean		14.2		

DECEMBER.

Date	DIRECTION FROM			Daily distance in miles.	Greatest number of mi. in any one hour of day	Maximum velocity in miles per hour.
	7 a.m.	Noon	7 p.m.			
1	w	w	sw	394	30	34
2	w	w	w	493	31	36
3	nw	w	sw	**550**	**32**	35
4	w	w	s	327	20	24
5	sw	w	w	458	29	33
6	e	w	w	266	22	26
7	w	w	n	307	22	25
8	n	nw	s	207	22	24
9	s	s	s	76	11	14
10	e	s	w	59	4	9
11	s	s	s	48	4	8
12	s	nw	ne	150	15	16
13	s	se	s	105	11	13
14	sw	sw	se	318	22	25
15	se	ne	se	107	13	17
16	s	w	w	201	23	25
17	w	sw	nw	228	20	25
18	s	se	n	82	14	18
19	se	sw	sw	139	13	24
20	ne	w	s	473	30	36
21	nw	nw	sw	290	20	28
22	sw	w	nw	383	25	30
23	nw	se	n	214	21	26
24	sw	ne	sw	255	23	26
25	sw	sw	sw	287	22	26
26	sw	sw	sw	417	25	29
27	w	w	sw	397	20	27
28	s	w	se	466	29	36
29	sw	ne	e	422	31	**37**
30	n	nw	s	257	24	28
31	w	w	sw	212	18	
Sum				8669		
Daily mean				279.6		
Hourly mean				11.6		

TABLE VII.—*Precipitation and Evaporation, (in inches), Laramie, Wyo.*

MONTH.	1891		1892		1893		1894		1895		1896		1897		1898	
	Rainfall	Evaporation	Rainfall	Evaporation	Rainfall	Evaoration	Rainfall	Evaporation	Rainfall	Evaporation	Rainfall	Evaporation	Rainfall	Evaporation	Rainfall	Evaporation
January	70	. . .	.01	. . .	T	. .	.03	. . .	.08	. . .	.44	. . .	.39	. . .	.05	. . .
February	.375	. .	.36	. . .	.11	. . .	.10	. . .	.14	. . .	.17	. . .	.16	. . .	.01	. . .
March	1.50	. . .	.52	. . .	.20	†	.20	. . .	.43	. . .	.59	. . .	3.97	. . .	.40	. . .
April	.25	. . .	.19	*	.32	24th to 30th .562	1.51	26th to 30th .903	.87	17th to 30th 2.530	3.53	. . .	.55	24th to 30th 1.80	1.28	15th to 30th 3.44
May	2.92	. . .	1.16	24th to 31st 1.59	.33	4.801	.42	6.060	2.09	7.334	.48	. . .	1.85	7.43	1.88	4.60
June	.91	. . .	3.07	8.23	.54	7.884	.64	7.492	2.12	6.236	.72	7.79	.72	7.73	.90	‡10.33
July	1.20	22d to 31st 4.424	2.22	9.19	.34	9.352	1.41	6.690	2.71	7.294	1.68	8.34	1.29	7.00	.65	8.37
August	1.76	8.500	.14	8.27	1.08	6.586	1.25	6.276	1.17	6.033	89	6.09	1.11	7.33	1.16	6 93
September	1.80	5.040	T	6.10	.39	6.015	1.60	6.435	.18	4.944	1.16	4.84	.32	4.84	T	5.68
October	.30	3.720	3.96	1st to 10th 1.50	.28	2.883	.09	3.303	.74	2.016	.18	to 22d 2.00	.55	to 26th 4.38	.48	to 15th 2.05
November	1.095	1st to 11th .928	T	. . .	.06	. . .	.05	. . .	.32	. . .	.09	. . .	.33	. . .	.61	. . .
December	1.11	. . .	.20	. . .	.10	. . .	.23	. . .	.33	. . .	. . .	. . .	.75	. . .	.23	. . .
Total	13.92	22.7	12.73	34.88	3.84	38.087	7.63	37 166	11.15	37.020	10.75	29.06	11.99	40 51	7.63	41.40

*Evaporation between November 11 and May 24 was 9.60 inches - liable to considerable error.

UNIVERSITY OF WYOMING.

Agricultural College Department.

YOMING EXPERIMENT STATION,

LARAMIE, WYOMING.

BULLETIN NO. 38.

SEPTEMBER, 1898.

TIVATED SHADE AND FOREST TREES.

BY B. C. BUFFUM.

lletins will be sent free upon request. Address: Director Experiment
, Laramie, Wyo.

Wyoming Agricultural Experiment Station.

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SILVER SPRUCE ON THE GROUNDS OF EDWARD IVINSON, LARAMIE.

ltivated Shade and Forest Trees.

B. C. BUFFUM.

Our mountains are covered with vast forests, while
plains and even our river valleys are practically
less. Belts, groves and scattering specimens of
onwood, boxelder, willow and alder are found along
streams for ten or twenty miles below where they
e the mountain range but farther down trees of
kind are generally absent or infrequent. At high
udes the banks of the smaller streams and even
e of the large rivers where they course through
mountain parks and valleys, frequently support
ree growth. At lower altitudes in the northern, central
eastern portions of the state small streams are often
ged with boxelder, occasionally a green ash is found
here and there a variety of bushes. In the extreme
h-eastern part of the state there are some good-sized oak
birch trees. That there are no trees along the lower
ses of our streams where the conditions of moisture are
rable has often been remarked, but as far as I know
not been explained. Undoubtedly the protection afford-
y the mountains favors the growth of trees near them,
the same species thrive when planted upon irrigated
nds farther away. Small willows are commonly found
whole length of the stream. Our observations indicate
cottonwoods either will not live or that they make poor
th upon soils which contain large amounts of alkali
. Willows which rapidly grow into trees will succeed
r than any other species on alkali ground. The absence
ees away from the streams is easily explained by the

lack of sufficient moisture. Sagebrush is found a everywhere and in certain localities where conditio moisture and exposure favor its growth it actually a the size and height of trees. Ordinarily it remains fro inches to two and one-half feet high.

It is not our purpose here to discuss the native fore pine and spruce further than to briefly state their e the danger of their extinction, and the necessity of preservation. It is estimated that approximately one the area of the state, or about 10,000,000 acres of land our borders, is covered with timber. All this the mountain regions and forms great natural st reservoirs which catch the snows of winter and them till late spring and early summer, giving a s supply of water when most needed to irrigate gr crops in the valleys and on the plains below. year fires started, either accidentally or purposely, bur thousands of acres of these forests. Irrigation is tl of our agriculture, and its future welfare in this largely depends upon the proper care and manag of the native forests. In addition they supply lumber and an abundance of timber for buildings, and wood. Although we have these great mountain f a class of vegetation greatly needed upon our irr farms and ranches is trees. Man's power to mitiga bad effects of climate and sudden changes of weathe himself or the animals and plants useful to him is cons increasing. He can overcome effects of weather in v ways but his ability to modify climate is limited. He houses and barns to shelter himself and his domest mals, and glass houses in which to grow the tender By planting trees, he provides a grateful shelter to h and his live stock and provides conditions under whicl plants can be made to succeed, which would not oth

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w at all. Shelter belts to protect animals from winds
storms are invaluable to the stockman. Protection
n the cold saves dollars and cents in the value of the
l which would be consumed merely to keep them warm.
n large ranches where there is more stock than it is
sible to provide buildings for, sufficient shelter belts
n prevent heavy losses from exposure during storms. A
l tree shelter of native cottonwoods is shown in the illus-
ion which was made from a photograph taken on the
oming Hereford Ranch east of Cheyenne. We repro-
e the cut through the courtesy of the Secretary of State,
. Burdick.

The influence of trees upon the growth of plants has
been given the attention and thought it deserves. In
y new agricultural region of the west old timers com-
ly remark that the climate has changed. When they
came to the country it was impossible to grow many
ts which now flourish. Apparently the meteorological
rds do not bear out the statement that there has been a
ge in climate, that the average rain-fall is more or less
at the temperature is higher or lower than for a series
ears twenty years or more ago. That fruit trees or any
r class of plants easily succeed now where in earlier
s they generally died, is well known. These first attempts
e made in exposed places where the winds and summer
had unchecked access to their tender trunks and
ches. It is true that many tender varieties were plant-
out even the hardier kinds did not flourish. As the
try develops, buildings and fences are constructed and
which is more important, windbreaks of hardy trees are
ted which temper the winds, shade from the scorching
prevent rapid loss of water by evaporation and make
place habitable for plants which could not live there be-
. The people who came to Denver and Northern Colo-
thirty years ago at first despaired of growing even har-

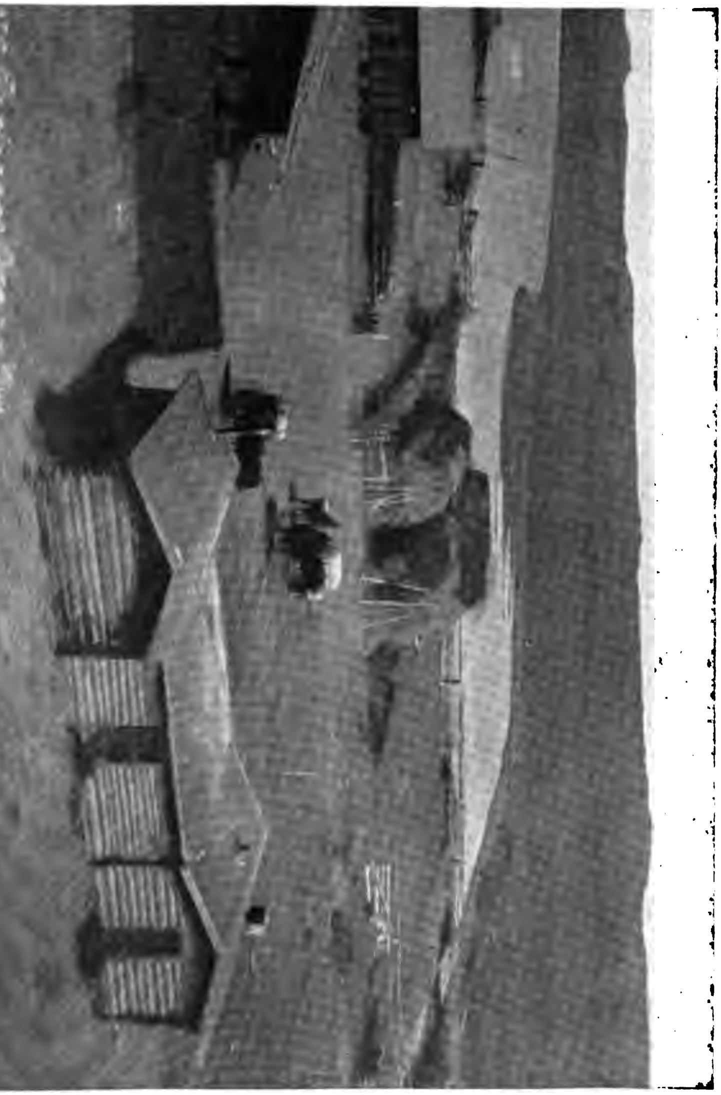
dy fruits and other crops. Now enormous quantities of f are raised and where sufficient shelter by surrounding h trees is furnished, even peaches are reaching perfection

In Wyoming we have the same conditions, and tha young orchards have succumbed to sudden severe chang the weather should not discourage the planter. Ther be no doubt that they will eventually succeed.

The kind of plants which are useful to man have made so by long years of cultivation and care, under c tions essentially different from ours. Therefore when p ed here they must be given such care and shelter as partially meet the conditions to which they have bee customed. By increasing the number of hardy native we produce the best wind-breaks. When enough of are growing upon every farm in a community the effect plants and stock is virtually the same as moving to a altitude or many miles to the south and the difficulti first experienced in raising many fruits no longer exist. these facts in mind it is readily seen that the plant trees is a public benfactor, not only of his own time b all time to come.

The kinds of trees to plant first are those which rally grow under the most adverse conditions. After become a protection more tender and desirable kind succeed. There are a few tree claims and wind-break side of our towns, but the majority of our farmers have the subject little attention.

The typical Wyoming ranch is everywhere thoug as a collection of low buildings, fences and hay stacks. out a tree in sight. Our picture is of such a ranch nea mouth of No Wood River in Big Horn County. This dition is rapidly changing, however. With the develop of the irrigated farm these temporary ranches are transformed into comfortable homes. In rural distric in towns the first plantings are for shade and ornamen



tically all the trees other than fruits planted in Wyo- g up to the present time have been set out for such)oses. In the interest of improvement and better taste vould discourage the usual methods pursued in so-called mental planting. Landscape gardening is the highest of art and in its practice he who imitates nature most ely is the best artist. Nature never planted her land- es with her most beautiful figures in rows, each row lly distant from its neighbor, the figures in the rows set qual distances and all in mathematical exactness with rd to every feature of the scene, yet how often is this ess followed out in the attempt to decorate home nds. Were it not for the far reaching influence of such tings in tempering the winds and climate and that trees here are beautiful in contrast to the usual barrenness of lain, I would say that it were better not to plant at all. uld not discourage rows of trees along our streets or es, ditches, and the borders of orchards and gardens for er belts. Here they become a part of the general me, are useful, beautiful, in place. In ornamenting the grounds let every yard be a landscape with har- ious effect, reflecting the artistic taste of the owner. A ral landscape delights us because there is variety, ir- larity, and curved lines of beauty everywhere. We can improve on such landscapes by adding variety while reserving harmony, and thus securing throughout a of order, unity and neatness. In planting yards, then, rees and shrubs along the borders with well designed es to give the effect of seclusion in one part and of open- and distance in another. A small yard can be made pear spacious by proper care exercised in the planting. s or objects which are grotesque or striking should r be put in prominent places as in the center or fore- nd of a lawn. In such localities they detract from the ony of the whole, by suddenly attracting the attention to a single incongruous object. The entirety of the s is marred or lost. By keeping these simple rules in every planter can produce effects which will be plea There is the greatest opportunity for indivuality and ch to secure results which have a meaning of their own. our somewhat limited list of trees which succeed in un tered places, there is consequently a necessity for ca thought and study to secure the best results in the end.

THE PLANTING AND CARE OF TREE

So much has been written on this subject that w only try to indicate that which seems to be the best pr for our state.

1. In taking up trees get plenty of roots. Prote roots to keep them from drying out.

2. The more roots the better. We do not belie root pruning.

3. A transplanted tree should be set in the groun same depth it was when standing in the nursery or before it was taken up, and no deeper.

4. A hole should be dug large enough to accom all the roots without bending or breaking them.

5. In setting trees spread the roots naturally. good soil in, around and over them, pressing it down. fill the whole with water. After the water has seeped finish filling with soil, packing firmly around the trun

6. Moderately prune back the tops of deciduous Cutting back large tree trunks when transplanting is practice, as they invariably die somewhat below the c coming unsightly, and from this nucleus decay is very

l, gradually creeping down the center or one side of
ain trunk, deforming and sometimes eventually killing
ee. Always make slanting cuts on top limbs and cover
ith shellac or paint.

The roots of evergreens should never be exposed to
r. When they dry out the resin or pitch in the bark
es thick and water will never again thin it.

After the tree is set out never let it suffer for water.
nwoods and willows need a continual supply but will
well if there is no drainage.

Never allow sod or weeds to grow immediately
d the trunks of trees. If the trees are planted close to-
r in groves or belts for wind-breaks the sod will not
e around the bases.

). In pruning trees cut out all dead branches. If for
oreaks or shelter allow the lower limbs to grow. In
g off a limb or branch never leave a stub on the tree
im it smooth with the trunk.

1. For ornament plant trees in clumps or groves in-
of rows. For shelter plant on the sides from which
ling winds blow. In this state this will almost invar-
be on the south and west. For general utility plant in
favorable place where they can be irrigated.

2. Use judgment in feeding trees and in preventing
s and disease from feeding upon them.

EXPERIMENTS AND OBSERVATION

In 1892 small plats were set aside upon the E
ment Farms at Lander, Laramie, Saratoga, Sheridan
dance and Wheatland for experiments with shade and
trees. In no case were the plats protected by wind-bre
other shelter, though the farms at Sundance and at I
were favored somewhat by being near the surrou
mountains. As few had attempted to grow trees th
object was to determine by trial what kinds would s
in each locality. The most of the trees set out th
year were two years old, though some seedlings were
In 1895 seeds of a number of varieties were planted
differences of altitude with accompanying weather c
and the conditions of climate and soil have produced
ent results in each part of the state. At high altitu
upon the Laramie Plains, the growing season is co
tively short. Sudden frosts in the fall arrest the gro
many trees before they have ripened their wood. S
the slow-growing kinds, as the hard-wood trees, fail
crease in size above the ground because each season's
dies back to the original stem or to the top of the
in the fall or winter. This has occurred year after yea
the ash, elm, and honey locust, and even upon the w
where given no protection or moisture through the
This is well illustrated in the picture of white ash a
trees showing six years' growth at Laramie, and of w
along the ditch in foreground of the picture showing
woods and willows of five years' growth at Laramie.
are two white ash at the left and a white elm at th
of the one foot rule. These trees were planted upon t
periment Farm when seedlings and irrigated each s
After having stood six years they were taken up and

aphed. A good root development has been made for the ze of the tops but the small whip produced each summer es down to the ground the following winter. As the al- ude decreases or more protection is afforded the season's owth increases and the dying back in the winter be- mes less frequent. In a protected place in Cheyenne a ousand feet lower than the Laramie Plains we have a cord of a season's growth on white ash of nearly three et while only a few of the top limbs died in the winter. Wheatland, two thousand five hundred feet lower than ramie, white ash made a growth in one season of fifty ches and no trouble had been reported of even the top ibs dying back.

The cause of the winter killing of trees and shrubs, as well set forth in Bulletin No. 15 of this station by Pro- ssor Aven Nelson, is the drying out during the winter. asons are also given in the same bulletin for believing that ch loss of moisture is greater at high altitudes.

That shelter by surrounding trees, buildings, or other jects which protected from winds, secures the same effect saving trees through the winter as does a lower altitude th its longer growing season, is well illustrated by the t that we have been unable to grow boxelders at all upon Experiment Farm while in sheltered yards in Laramie trees have attained considerable size.

The following notes indicate briefly the results of our ils with different trees, the general hardiness and utility each and how they may be propagated or obtained.

COTTONWOODS (*Populus.*)

Five species of poplars have been found native in the te.* Three of these are commonly called Cottonwoods, the Balm of Gilead and the other the Quaking Asp.

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*See Bulletin No. 28, p. 180.

The poplars are diœcious, i. e., the male and fen flowers are borne on separate trees. As the cotton is suc nuisance in yards and along the streets it is quite import only to plant in such places the male trees, which prod no cotton. We know of no way of telling the trees wl produce cotton from those which do not when the young, but it is an easy matter to propagate the kind wan Cottonwoods grow readily from cuttings. Cuttings fi male trees or those which do not bear cotton will prod male trees. Anyone raising their own trees from cutti should bear this in mind, in order to get rid of this ob tionable feature. Some trouble has been experienced this state by such rapid growing trees becoming bark-bou especially on the south and west sides. When this occ split the bark open up and down the trunk once or tv during the season. Cottonwoods will grow in most try situations if given plenty of water. They have succee better with us where planted upon rather shallow soil v sandy or gravelly subsoil and given a continual suppl water. In regard to their general usefulness, Profe Bailey of Cornell, writing for New York State, says: "A group, the poplars possess comparatively small valu landscape planting. * * * A very rapid growing tree ne always produces cheap effects. * * * There is little suggests strength and stability in willows and poplars for this reason they should always be used as mino secondary features in ornamental or home grounds. W quick results are desired there is nothing better to plant these trees,but better trees, like maples,oaks,or elms,sh be planted with them and the poplars and willows sh be removed as fast as the other species begin to afford tection. * * * The cottonwood is perhaps the best of spreading its gray branches far and wide, but like the as it is cheerful and restive. One is not moved to lie und as he is under a maple or oak. Its leaves rustle with

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st movement of air. The ripple of its foliage always to my mind the play of wavelets upon a pebbly shore. ıy is never so dark but the cottonwood reflects a f light."

rce of circumstances necessitate our disagreeing with of these remarks, for we would be loath, indeed, to l the cottonwood for our permanent plantings. The r of kinds of trees which we know to be hardy enough d our climate is limited. In fact, the only one which ıy great use for shade at the altitude of a great part state is the cottonwood. We admit that their con- moving foliage is not conducive to the midday but on the other hand they are emblematic of the ner- ıergy, the bustle, the push characteristic of western Once for all we might as well decide to accept the vood with thankfulness that we have so noble a d set about conscientiously to make the best use pos- ' it in producing pleasing effects in our landscapes.

DBERG'S COTTONWOOD OR SMOOTH BARK.

(*Populus acuminata* Rydberg.)

is is the hardiest and best of our native cottonwoods livation in this state. It will grow anywhere if suffi- oisture is supplied, and thrives especially well where er are planted together, as they shelter one another. ount of its hardiness, rapid growth, and habit of as- a good shape, there is nothing to equal it for gen- ınting under adverse conditions, or for a first shel- protect more tender species. It is especially use- wind-breaks, for planting along our streets, and single ens standing near the border of a yard are beautiful. specimens planted upon the Experiment Farm at e have succeeded well, making several times as much as the broad leaved cottonwood.

an altitude of over 7,000 feet trees one inch in diam-

eter will become five to seven inches in diameter
years. Every ranchman in the state who can irrigat
should plant shelter belts and wind-breaks of this
and should have them in his yard for shade. Cotto
are greedy feeders and other trees or plants do not
when planted too close to them, but their good in
will repay the amount of room required. This tre
true of all our native poplars, produces good fu
is of little or no value for lumber.

BROAD LEAF COTTONWOOD OR CAROLINA PO

(*Populus deltoides* Marsh, or *P. monolifera* Aito

This tree is common at Wheatland and in the
western portion of the state. Around the first a
lakes or reservoirs at Wheatland thickets of these tre
up from seeds which made their way down the ditch
the irrigation water. It is much used as a shade tree,
are some excellent specimens in Laramie. Seedlings s
the Experiment Farm in 1893 subject to the exposur
open plains have lived, though the growth has bee
paratively slow. They have attained a height of e
ten feet and a diameter of two or three inches. Th
undoubtedly been dwarfed somewhat by injury fro
lice which were found in great numbers on the le
1896 and 1897. Prevailing southwest winds have
them to lean in the opposite direction. A few specim
shown in the illustration of this variety, at Laramie.
on the plat were removed to make room for the s
stack shown in the cut.

At Wheatland small trees set out upon the Exp
Farm in 1892 became four inches in diameter and
to fifteen feet high in three years. This species is n
sirable for general planting especially at high altit
is the smooth bark or Rydberg's Cottonwood.

NATIVE BALM OF GILEAD, LARAMIE

RROW LEAF COTTONWOOD OR BLACK COTTONWOOD.

(*Populus angustifolia* James.)

This is one of the most common native species, often ving to great size. It is hardy but at high altitudes is to become scrubby and unsightly where not well cared and systematically pruned. Many of these trees have planted in towns and some are making a good appear- . Some of the finest trees in Laramie are of this species. oes not grow so rapidly as the smooth bark, but when e its great spreading tops make it as effective a tree. narily it is not so highly prized as either the smooth or broad leaf given above.

BALM OF GILEAD. (*Populus balsamifera* Linn.)

Apparently this tree is not abundant in the state. There nsiderable variation in the shape and size of the leaves they can be usually distinguished by the resinous or y buds. This tree is long lived and hardy, succeeding almost everywhere, although the broader leaved eties have been more or less tender in Laramie. Pro- r Bailey states that their tops are hardly broad enough he best shade but are good to plant among other trees. sticky buds and leaves collect too much dust and dirt ake them desirable in cities where there is much smoke. illustration made from a protograph of one of these in Laramie shows a broader head than is generally ed by this species. Balm of Gileads are reported as not g well upon the Lander Farm as they require so much r that other things are injured by it.

KING ASP OR ASPEN. (*Populus tremuloides* Michx.)

Many of these trees have been transplanted but I have o see one in cultivation which I consider a fine specimen. Those which have been transplanted do not seem to grow well, probably because they do not receive sufficient moisture through the winter. They are pretty trees, throwing out their catkins before others have started in the spring, bearing through the summer their gay foliage which is never still, and at the first heavy frost in the fall turning to bright yellow and gold. They are useful for planting in yards with other trees as single or scattered specimens and are more esteemed than the cottonwood for setting out in young evergreen plantations to shade and protect the trees.

HORTICULTURAL VARIETIES OF POPLARS.

There are a large number of varieties of poplars in cultivation, other than those which are native to this state. I only know of one of these which has been introduced here. This is the Lombardy Poplar, specimens of which have been noticed in several places. It is a short-lived tree, however, and probably will not be planted to any extent. Such striking growths are too often abused by being used indiscriminately where they produce unpleasant effects in the landscape We have little regret that the Lombardy does not succeed well here as is it of so little value for shade, ornament, wood or timber. The so-called silver poplars which have been planted here are silver maples, spoken of under maples, rather than true silver poplars. A number of Russian Poplars have been introduced which would, no doubt, prove of value for planting in this state but as yet they have not been tried*.

WILLOWS. (*Salix.*)

The willow is fully as hardy as the cottonwood but is not as useful for all kinds of planting. They are easily propagated by cuttings but they require a large amount and a

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*Anyone interested in these poplars should obtain Bulletin No. 9 of the Minnesota Experiment Station, St. Anthony Park, Minn. and Bulletin No. 68 of the Cornell Station, Ithaca, N. Y.

N (WHITE) WILLOW IN YARD OF EDWARD IVINSON, LARAMIE.

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inual supply of water. Some of our native willows grow large size but they do not produce a shapely tree. They easy to cultivate, however, and may be used to advan- in many places. Our illustration of a screen of native ows represents their usefulness for this purpose. These ows grew from cuttings in three years. In this case are used to separate the garden from the house and t lawn.

A so-called Russian willow[*] has been grown upon the eriment Farms at Laramie and Lander. Upon the Lara- Farm they have died down to the ground nearly every ter. A few specimens which had more moisture have ined a larger growth, but, as a rule, they only produce a ge of whips along the ditches, as shown in the illustra- of cottonwoods and willows upon the Laramie Farm. ger trees of the same species have succeeded well upon University Campus and Mr. L. Fee has experienced little culty in raising effectual wind-breaks of them upon the r bottom.

If kept properly trimmed they form a shapely tree in a t time. We show a picture of one of these trees on the nds of Mr. Ivinson as it appears three years after trans- ting. At Lander they produced a fairly good wind-break nree years, having reached a height of twelve to fifteen The larger ones now have diameters of from two to inches.

Osier willows brought from Nebraska have succeeded upon the Laramie Plains. Upon the ranch of Mr. James g, seventeen miles from Laramie, they have made large vths, producing an effective wind-break for his garden. pecimen upon the Experiment Farm which stands near main lateral where it gets plenty of moisture has grown and shows no tendency to winter kill.

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[*] Our botanist, Prof. Nelson, sent specimens to Prof. Bebb, a few years ago, who stated is was the white willow crossed with another species.

MAPLES. (*Acer.*)

So far as we are informed the hard or sugar ma not been tried other than a few seeds planted on the Farms, which failed to grow. Soft maples will suc sheltered places below five thousand feet altitude. planted at Laramie have failed. Three species are in the state, the small bush maple, common in moun vines; the boxelder, along nearly all our streams at titudes, and our botanist has found a species, th maple, on Bear River near Evanston. The following deserve special mention:

Boxelder (*Acer negundo* Linn.)—Boxelders a tender above 7,000 feet altitude except in the mo tered locations. They may be sparingly used in where they often produce handsome trees. Seeds on the Experiment Farms have not succeeded very cept at Lander, where seeds planted in 1895 have p trees two inches in diameter and twelve feet high. are subject to attacks of the boxelder leaf roller whi be kept in check by spraying or the trees become a as long as they live and are eventually killed by t sects. (For remedy see Insect Pests.)

Silver Maple (*Acer saccharinum* Linn.)—This sp often planted in our towns under the false name o Poplar. It is hardy but shows a tendency to die bac winter at Laramie. It has a disagreeable habit of ing from the roots, and if neglected soon forms an u bramble of underbrush. Single specimens, well care the back yard, may be tolerated, but they are too striking for good effects in front yards or along th Our illustration shows some fair specimens plant a street in Laramie.

SILVER POPLAR (MAPLE), LARAMIE.

LOCUST. (*Robinia.*)

Honey Locust planted on the south side of the Univer- campus lived four or five years, but did not increase in as the small growth made each summer died back to main stem the following winter. At Lander a good d of both Honey and Black Locust was secured from , but reports from there state that they are killed back winter. In a yard in Laramie there are good specimens lack and Yellow Locusts, but they have not been grown enough to determine whether they can be made to live ugh the winter or not. Fine specimens of these trees been observed in Cheyenne. They will undoubtedly eed in Wheatland and at other places along the eastern er of the state.

CATALPA.

This species has not succeeded upon the Experiment ns. It can probably be made to grow in sheltered places w altitudes.

MULBERRY. (*Morus.*)

The Russian Mulberry tried upon the Experiment Farms been killed during the winters. We have seen fine ty trees full of ripe fruit at nearly seven thousand feet ide upon the ranch of Mr. Keach located in a protected y in the mountains about twenty-five miles south of Vyoming line. With proper protection they will un- tedly succeed in parts of the state.

GREEN ASH. (*Fraxinus lanceolata* Brokh.)

The Green Ash is found native along streams in the ern part of the state, having been observed as far south e Canon of the North Platte above Orin Junction. It ndoubtedly succeed where properly cultivated in that n.

WHITE ASH. (*Fraxinus americana* Linn.)

The investigations by the station show that the Ash needs a longer season than we have at altitudes six thousand feet. The illustration of White Ash and grown from seedlings at Laramie show the small g made in unsheltered places. Larger trees set out up Experiment Farm and the University Campus lived th the first winter but made very small growth. In Che at six thousand feet altitude, there are some thrifty shaped ash trees. In the railroad park near the depo made a growth this season of from one to three feet. many White Ash were set out around the Capitol gr The State Engineer tells me he has concluded that the is too short for them.

At Lander, Sundance and Wheatland they hav ceeded well. At Lander they made a growth of over feet in the season of 1895, but the heavy freeze on Sept 22nd of that year cut them back. Since that time the made new growth and Mrs. Meyer reports now that th two inches in diameter and nine feet high. We h report on the White Ash from Wheatland since 1895, that time trees which were set out when one year old had made a growth of six to ten feet high and about o one-half inches in diameter. Our illustration of Whi trees at Wheatland shows a growth of four feet two in 1895.

WHITE ELM. (*Ulmus americana* Linn.)

The larger trees of White Elms planted at Laram the first season. Seedlings set out in 1892 have liv have made such small growth (see illustration) that th difficult to see in the plat. They seem hardy at Whe where in three years they reached a diameter of two a half inches and attained heights of ten to twelve fe Lander they have died back each winter. In nea

WHITE ASH TREE. Wheatland, 1895. Season's Growth, 4 ft., 2 in.
(*Cut loaned by Hon. J. M. Carey.*)

ts of the state they will require good shelter in order to ceed.

UTTERNUTS AND BLACK WALNUTS. (*Juglans.*)

At Wheatland and at Lander Butternuts and Black lnuts have lived but have only made small scrubby wths. In 1895, at the former place, they made a season's wth of two feet. Black Walnuts are more hardy than ternuts at Wheatland. Trees set out at Lander in 1892 now about two inches in diameter at the ground and four high. They require a low altitude and the best of shel- from the wind and sun.

MOUNTAIN ASH. (*Pyrus americana* Marsh.)

This is a very ornamental little tree where it can be le to thrive. It is native to the state in ravines in the ntains above 8,000 feet. A dozen were set out at Lara- but we failed to make any of them live. They require a tered locality and plenty of snow or other moisture dur- the winter. In Cheyenne there are a few beautiful imens.

BIRCH. (*Betula.*)

There is a native species in the Black Hills of Crook nty. We have not attempted to grow them upon the eriment Farm but believe them worthy of careful trial rnamental planting.

FRUIT TREES FOR ORNAMENT.

Those fruit trees which succeed with us are of little e for shade. However, they can often be used to ad- age associated with other trees in ornamental planting their usefulness makes them doubly desirable. Some he apples, as the Wealthy and the Siberian Crabs, are st as hardy as cottonwoods and willows. They may be planted with considerable freedom in the rear and sides of city lots and single specimens well placed are attractive. The same may be said of hardy cherri plums. Mr. O. D. Shields of Loveland, Colo., has b out a new creation in the form of a weeping cherry appears to be very hardy. It consists of the Rockey tain Dwarf Cherry (*Prunus Besseyi*) budded upon stocks. It makes a rapid growth, is weeping in hab the long silvery leaves give it a thrifty, handsome ance. It is a promising small tree to be used as singl mens in recesses between other trees or near gro shrubs used to break the lines of buildings or fences.

EVERGREENS.

Up to the present season we have only attem grow evergreens upon the University Campus at L Last spring the Division of Forestry of the United Department of Agriculture sent us about 25,000 s trees of Scotch, Austrian and Bull Pines. They we fully planted upon the Experiment Farm according t furnished by the Department and have been irrigate during the summer to keep them from drying out. two thousand of them were protected by setting s on the south and west sides. At the present writin twenty-five per cent. of those set out are alive. The shingles has apparently made no differnce in the dea We have tried to grow evergreens upon the Un Campus for six or seven years but with poor succe stead of scattering specimens we are now planting in with the hope that by supporting and protecting other and catching the winter snow they will liv transplanted at different times of the year but the ments have not been under way long enough to enab report results. We have planted only native trees t in our mountains or those raised in a nursery. In p

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s in town many have succeeded better than we. The fol-
ving varieties merit special mention:

Silver or Blue Spruce (*Picea pungens* Englm.)—This is a
id growing tree and the most beautiful of our evergreens.
is a native, growing along streams or in wet swampy
ces in the mountains. On account of its natural habitat
s the only evergreen which grows well upon our lawns
ere so much water is used. When small it closely re-
ibles the Engelmann Spruce but the latter grows on high
und. Nurserymen claim to have little difficulty in grow-
Silver Spruce but our experience indicates that they can
dly be made to succeed where no protection from winds
l sun is given. Out of dozens of them set out without
tection we have succeeded in establishing a single tree
ve know it is growing. A number recently set out seem
e growing well. There are many fine specimens in the
ds and parks in Cheyenne and Laramie. Mr. Thessen,
was caring for the railroad park in Cheyenne this sum-
, states that he has not lost a single tree. The grass is
allowed to grow around the bottom of the tree trunks
when watering the lawn the tops of the spruce trees are
iyed every day. As our frontispiece we show an illustra-
of a very good specimen in the yard of Mr. Edward
son in Laramie. This tree was transplanted to its pres-
position about ten years ago when it was quite small.

Douglas Spruce (*Pseudotsuga taxifolia* (Poir) Britton.)—
is a common tree in our mountains which is sometimes
isplanted with the thought that it is the Silver Spruce.
are easily told apart, however. It stands transplanting
y well if carefully done but will not thrive where there
much water as is required by the Silver Spruce. There
some fairly good specimens in yards in Laramie. Our
ire shows a small grove of Douglas Spruce which has
set out on the University Campus the past two sea-

sons. This picture represents the manner in which we the trees are more apt to grow by protecting one an and catching the winter snows and illustrates the c method of producing artistic landscape effects.

Cedars (*Juniperus.*)—Cedars do not seem to have kindly to transplanting in Laramie. There are som specimens in yards in Cheyenne. Single specimens ar ornamental, especially if properly backed by other so they form a part of the whole effect. The cultivate ety should be obtained from some reliable nurseryma

ARTIFICIAL ROOT PRESSURE.

The artificial application of root pressure in hortic is new. It has been introduced by Professor E. S. the Wisconsin Station. He gives a detailed account periments carried on along this line in the Fourteen nual Report of that Station. Professor Goff attribu failure to start growth promptly after trees have transplanted to the lack of sap pressure in the cells. normal conditions this pressure is supplied by the ac root hairs. These, of course, are destroyed in the of transplanting. New root hairs must be produced the plant can re-establish this sap pressure. During t that the tree is taking up so little moisture from the s continually losing a large amount by evaporation naturally lowers its vitality and ability to make quic growth. It seems plausible, therefore, that artificiall ing up the pressure in the tree, supplying water to t place of that lost by evaporation and continuing the conditions so it can perform vegetative functions w sure the life of the tree and accelerate its growth. P Goff has demonstrated the value of his method wit planted apple trees. We have tried the method up trees at Laramie and, while our experiments were

sive, it seemed very beneficial. Our object in presenting
matter in this bulletin is to interest those who are plant-
trees of any kind, with the hope that they will co-
rate with this station in order to make the experiments
iciently extensive to determine what value attaches to it.

The method is so simple, inexpensive and easily applied
t anyone can use it and if it proves effectual in prevent-
the death of even a small percent of transplanted trees
ould pay for itself many times over. When the trees are
nted a receptacle holding distilled or rain water is placed
the height of, or a little above, the top limbs and con-
ted to one of the roots of the tree by a tube and small
e of rubber hose. Bottles and glass tubing or a metal
h at the top of a piece of gas pipe may be used. It is not
imed that attaching this apparatus will do any good ex-
t during the time new root hairs are being formed, the
ts are establishing themselves and the new leaves are
rting. It is only needed a few weeks at the most and the
terials used can be utilized for other trees. Anyone who
l co-operate with the station in making tests upon newly
nted trees will confer a favor by corresponding with the
ector. We only care to experiment with it upon spring
nted trees, but sould like to make careful tests upon any
ls of trees, whether deciduous or evergreen and in differ-
parts of the state.

INSECT ENEMIES.

Only a few insects which produce any alarming
to our trees have been observed. There are a few, ho
which demand immediate attention and energetic act
order to prevent the destruction of our hardiest va
It is not our purpose here to write a scientific treatie
this class of insects, but to call attention to the dange
certain pests and give as briefly as possible remedi
their destruction.

PLANT LICE.

These are the most injurious insects in the state.
are especially destructive to cottonwoods and hav
very injurious to willows and spruce These wonderfu
insects are known to everyone as plant lice or as "gr
brown flies. They are so small that even when they o
great numbers they are easily overlooked and thoug
fatally damage the trees the work is done so unobtr
and slowly that they are too often ignored. There are
many genera and species of plant lice but it will
necessary to describe or classify them here. Two
working on the cottonwood are named in Bulletin
this station.*

"The two species of lice in this locality on the
wood are *Pemphigus populimonilis* ? Riley, and *Chait*
viminalis ? The former is less numerous than the
The first-named species attacks the leaf near its marg
the continual puncturing and irritation to the l
growth is retarded at this point. The growth on th

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*This bulletin which was written by F. J Niswander, then with the Station,
hausted. As it can no longer be supplied I have quoted in full the section on species
further along the one on remedies.

side of the leaf is so rapid that within a short time a :et-like cavity is formed, in which the lice live. The other :ies differs in its habit from its relative. Instead of form- a gall or protective covering for themselves, they con- gate upon both sides of the leaf near the midrib and by r continual puncturing soon cause the foliage to curl, be- e brown and finally drop from the tree." Undoubtedly e are other species working upon the cottonwoods and ows. We have not observed that early dropping of the es generally follows the attacks of our common species. ave also found undoubted evidence of work upon the s by one or more other species.

Plant lice may or may not produce galls either upon the es or roots, depending upon the species. Where there attacks upon both the leaves and roots more serious in- is done in a short time. They are so destructive to the onwoods in Laramie that unless some change in natural litions, as unfavorable seasons or the increase of their nies, destroys them or unless the people take the matter and, we predict that in ten years' time there will be very trees left. The trees gradually become weak, but they not show the bad effects until time of throwing out the es in the spring. The foliage comes out late and the es have a small, yellow, sickly appearance. After strug- g along after this manner for one or more years, the en- :ree dies. Where neglected by not being prunned or sup- l with sufficient water they die more quickly. Our illus- on shows trees on a street in Laramie which are being :oyed in this way The one to the left in front is entirely The one back of it, inside the fence, and the three to ·ight are so out of health that they will probably not into leaf another year, while the large, green tree at the shows little effect as yet and may live several years. trees in this picture are typical of the condition of a

great many cottonwoods in Laramie and every tree c
shold do something at once to prevent further destru
These insects live by sucking the juices of the plant
which they feed. They ordinarily collect in great nu
on the under side of the leaves or upon the roots
ground. Upon their backs, near the rear end of the
they bear a pair of siphuncles or honey tubes, through
is secreted a sweet liquid known as honey dew. This
becomes sticky and where the lice are numerous often c
the leaf, helping along the destruction of the tree by ch
it to death. Sometimes so much honey dew is excrete
it falls like rain, and walks under the trees are c
with it.

Ants are the friends of plant lice, attending them
larly to feed upon the honey dew and caring for th
their eggs through the winter. It has been proven t
least some species cannot live unless they are taken c
by ants. If this is true of the species affecting our c
woods, and it seems likely, destroying the ants is a
remedy. Mr. Ivinson informs me that they have des
the ants wherever they have been found on his groun
pouring boiling water into their nests, and that his
have not been bothered by lice. So far as I have obs
they are the only trees in town which do not show
from these insects. For destroying ants, there is pr
nothing better than bisulphide of carbon. Pour two o
tablespoonfuls into each hole and press the soil aroun
over it with the foot. This will usually kill everyt
the nest.

There are several kinds of plant lice which live
evergreens. They are often numerous on the D
Spruce, and one species (*Chermes abietis* Linn.) pr
small, brown, cone-shaped galls at the ends of the li
the silver spruce.

REMEDIES.—Professor Gillette of the Colorado Sta-
recommends collecting and destroying the galls on the
e during the last half of June or early in July and to ap-
erosene emulsion during the latter part of May. He
states that kerosene emulsion is effectual in killing the
n Douglas Spruce.

When there are lice on the roots of trees they may be
oyed by working from three to six pounds of tobacco
or a good quantity of the stems into the soil around the
of the tree and then thoroughly wetting it. The water
enough nicotine from the tobocco down around the
to destroy the lice. Professor Smith, in his book on
nomic Entomology" (P. 131), says salty liquids will kill
lice, and recommends the use of potash fertilizers
nd the trees. Bisulphide of carbon injected into the
nd is sometimes used and is effectual in killing the in-
but it is more expensive than tobacco and, using too
, is apt to injure the tree. It is necessary to destroy in-
which feed, as do the plant lice, by applying poisons
kill by coming in contact with their bodies. All that
d to say regarding remedies for the lice on the parts
ground and how to prepare and apply them is con-
d in the following quotation from F. J. Niswander, in
ning Bulletin No. 2: "Various remedies have been sug-
d for the destruction of plant lice, but none seems to be
effective than an emulsion of kerosene oil and soap.
emulsion is made as follows: 'Dissolve in two quarts
t water one-fourth pound of hard soap by heating to the
g point, then add one pint of kerosene oil and stir vig-
ly for from three to five minutes.'—(Cook). The best
do the stirring is to pump the mixture from one vessel
nother or back into itself with the force pump. This
orm a thick, creamy mass that may be diluted to any
d strength. To the mixture just formed we then add

ten pints of water. This is the usual strength, althou emulsion will kill the lice if twelve pints of water are It is better to add the larger amount of water, as th some damage done the foliage when only ten pints are The emulsion should always be applied with a force Another excellent remedy for plant lice is Buhach or thrum. This is the yellow insect powder sold in the for the destruction of insects. If two tablespoonfuls be thoroughly stirred in a large pail full of wate sprayed upon the trees excellent results will follow t plication. Too much care cannot be taken to make ough application, otherwise it will do no good.

"In the application of insecticides there is nothin will insure success like thoroughness. A dashing spr that will reach every leaf upon all portions of the tree of the essentials of a good force pump. There are pumps upon the market and all have certain feature are commendable."

BOXELDER LEAF ROLLERS.

(*Cacœcia semiferana* Walk.)

This insect proves very destructive, at times prac defoliating the boxelders, leaving them unsightly such condition that they are slow to recover. It is po thought to be the same as the leaf roller of fruit tre Bulletin No. 47 of the Colorado Station, Professor C. lette, in speaking of it, says: "This insect is a close r of the Fruit Tree Leaf Roller and it is quite con thought not to be different It seems to confine its exclusively to the boxelder, however, in this state, as never yet found the larvae feeding upon anything el habits and appearance are much like the fruit tree s

REMEDIES.—As the larvae are external feede ing the whole leaf, they may be destroyed with any stomach poisons. Spray with Paris Green mixed wit he rate of one pound of Paris Green to 150 to 200 gal- of water, keeping it well stirred. Apply when the young ae first appear upon the leaves and again a week or ten later.

BOXELDER BUG—(*Leptocoris trivittatus* Say.)

This insect is common all over the state. It is a flat bug it one half inch long, black, with red margins on the tho- and wings. They may often be seen walking around ly in the fall or winter time, or collected in great num- here and there. The young bugs feed upon the box- r.

REMEDIES.—Professor Gillette says that the old bugs n proof against most applications used for such in- s, but that kerosene emulsion will probably kill the ng bugs. He recommends killing them with boiling er when large numbers of them are found collected in place.

ATTACUS MOTH—(*Attacus columbia* Smith.)

A large, green caterpillar, almost the size of a cigar, n full grown. covered with knobs, with yellow and blue kings, is becoming a common pest upon the willows, cur- s and gooseberries at Laramie. They are enormous eat- requiring a great many leaves at a meal, and have a habit nly resting a short time between meals, so entire iches may be defoliated in a single day. The larvae spin cocoons of silk and produce the largest moth found in state, the wings expanding three and one-half to four es.

REMEDY.—Where numerous, they should be destroyed the same spray of Paris Green as that given for Box- r Leaf Roller.*

A number of caterpillars have been found eating the willows. Wherever they feed in mbers as to be at all injurious they should be destroyed with the Paris Green spray ffectually kills any insect which feeds by eating a part or all of the leaf.

TENT CATERPILLAR—(*Clisiocampa fragilis?*)

Specimens of tent caterpillar eggs have been se from Natrona and Crook Counties. The eggs are laid i dles around the stem. The larvae feed upon the apple ning unsightly tents in the top limbs, and become v structive where allowed to become numerous and co their ravages unmolested.

REMEDIES.—The egg masses must be cut off winter and burned. If any escape observation, the can be destroyed by cutting off and burning the tents spraying with Paris Green. Where the trees are s with Paris Green for the codlin moth the tent caterp usually destroyed as well.

COTTONWOOD BORER—(*Prionoxistus robiniæ* P

Injury from this insect is occasionally met with tonwoods in this state. They are apt to bore into t where there is a scar. The castings of the borers are out to the surface and the sap runs out, making a b place on the tree, which helps to rot the wood. The become about two inches long.

REMEDIES.—As given by Professor Gillette, th dies are to destroy the larvae by using a wire or to his coming out as the adult moth by plugging up the tacking a screen over it. It is difficult to destroy wo ers because they are so inaccessible.

SUMMARY.

Fifty million acres in Wyoming are treeless. About
million acres are now under ditch and large tree plant-
are needed on every farm.

The influence of trees makes it possible to grow fruits
other plants which would not otherwise succeed.
ter belts are invaluable protection to live stock. With-
rees our landscape and homes are monotonous and un-
ctive.

As a people we should give more thought to the plant-
care and pruning of our trees.

Our best trees for wind-breaks, shelter belts and street
ting are cottonwoods and willows. Our most rapid
ing cottonwood is the smooth bark or Rydburg's. Next
lue are the broad leaf, black or narrow leaf cottonwood
Balm of Gilead.

The cause of the winter killing of our trees is believed
their drying out during the fall, winter and spring. The
dy indicated is fall and winter irrigation, protection
wind and sun, catching the snow and any method to
ent evaporation, as mulching the ground and wrapping
rees.

The following list gives the trees which have been tried
e state for ornamental or other planting, arranged so
s we are able to do so, in the order of their hardiness,
ost hardy being named first: Cottonwood, Willow, Sil-
Spruce, Douglas Spruce, Boxelder, Hardy Apples,
f Cherry, Silver Maple, Cedar, White Ash, Green Ash,

Locust, Elm, Morello Cherries, Plums, Mountain As Maple, Black Walnut, Butternut, Birch, Mulberry, C

Our cottonwoods and boxelders have been more by insects than other trees.

The insects doing greatest injury to trees in thi are plant lice, the boxelder leaf roller and tent an caterpillars.

For insects which feed by sucking the juices of as plant lice, spray with kerosene emulsion. Those upon the roots may be destroyed with tobacco an phide of carbon. For those which feed upon the lea a spray of Paris Green. For ants, use bisulphide of ca hot water.

UNIVERSITY OF WYOMING.

Agricultural College Department.

YOMING EXPERIMENT STATION,

LARAMIE, WYOMING.

BULLETIN NO. 39.

DECEMBER, 1898.

ALKALI STUDIES, II.

BY E. E. SLOSSON AND B. C. BUFFUM.

ulletins will be sent free upon request. Address: Director Experiment
n, Laramie, Wyo.

Wyoming Agricultural Experiment Station.

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Alkali Investigations.

E. E. SLOSSON.

THE CHARACTER OF WYOMING ALKALI.

The Experiment Stations are supported for the purpose
scientific research in the problems of agriculture and they
located in different states in order that each station may
dy, at close range, the conditions of the region that sur-
nds it. From its location the chief problem of the Wyo-
ng Station has been given to it by nature, the study of ari-
y, and as fast as possible the work of the Station has been
centrated on this subject.*

The chief difficulties in the way of agriculture in the
l region are two, the insufficient supply of water and the
umulation of soluble salts, known as alkali. The second
he these is a consequence of the first. Where watering
one by rain, pure water is added to the soil and drained
underneath, carrying with it the soluble salts of the soil.
rrigation, water containing salts is added to the soil and
e water evaporated from the surface. It was shown in
letin No. 24 that half a ton of alkali was added to each
of the Sheridan Farm every year by irrigation and the
l became completely useless until it was drained.

Samples of alkali from all parts of the State have been
lyzed and the complete analysis will be published in the
t annual report. It will be sufficient to give here the

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*For a summary of the publications of the Station on this subject, see Eighth Annual Re-
898. pages 15-50.

general result. Almost all the alkali of the State co of three salts in varying proportions, sodium sul (Glauber's salt), magnesium sulphate (Epsom salt) a dium chloride (common salt). The "black alkali," s carbonate, is fortunately very rare as it is much mo jurious than the other salts. Analysis of the soils State shows that the percent of soluble salts or alkali ually small, often extremely so, and it is only its accu tion at the surface that causes damage. On the other the small amount of water in the soil makes the alkali injurious than if more diluted, for it must be remem that it is not the total quantity of alkali in the soil b strength of the alkali solution that is of importance example, if the soil contains 10% of water about 3% o mon salt is required to form a saturated solution, there is only 5% of water half that amount of salt wi duce the same effect and any larger amount is no wors unirrigated land the water content is mostly between limits. (Bulletin No. 35.)

In many parts of the state the alkali salts are not together and distributed through the soil, but are co in large beds of single salts often very pure. Near L there are beds of sodium sulphate, near Rock Creek o nesium sulphate and near Green River of sodium car (sal soda) of many acres in extent and several feet in ness. Many theories have been advanced as to the or these "alkali lakes," mostly based on the assumptio they must have been made from the decomposition o containing the same salts. Since there are no rocks vicinity whose products of decomposition at all re the alkali, the advocates of this theory have been to construct hypothetical rocks for the purpose. I ever, we remember that the salts deposited from s depend on the proportions, temperature and concent and need not be at all the same as the salts dissolv

account for the alkali beds without taking into consid-
ion the origin of the salts. It is enough for us to know
all the spring and river waters of the state contain the
essary elements and the problem is merely to separate
n into the forms that are actually found.

The salts in the alkali lakes can not be regarded as of
certain composition. They become liquid, that is dis-
e in their water of crystallization on a warm day or are
olved by the addition of rain water and when deposited
ooling or evaporation it would be very improbable that
same forms should reappear in the original proportion.
n too the addition of drainage water containing more
s must change the equilibrium and cause a rearrange-
t to form new salts. This may account in part for the
ely variant analyses that have been published, and ob-
ations at different seasons of the year show startling
ges. Sometimes the lake is fluid, at others solid. Some-
s it is a bed of large clear crystals of sodium sulphate
hydrate; sometimes the white anhydrous sodium sul-
e covers the surface. The phenomena can be watched
prettily by dissolving the salts in a beaker of water in
proportions and concentrations as to be in unstable
librium. If the temperature of the room varies consid-
ly the form, size and composition of the crystals will
be very different.

The salts contained in natural alkali are remarkable
he number of their phases. We have in the natural
rs of the State from which the alkali is deposited, the
s sodium, calcium and magnesium, and the acids car-
c, sulphuric and hydrochloric. There are also some-
s present the bases potassium, aluminum, iron and
m, and the acids nitric, boric, silicic, phosphoric and
ed sulphuric acids, but only in such small quantities
they do not play any important part in the formation

of the alkali deposits. Evaporation of a solution con ing the above six factors might form nine simple salts a great number of double salts and hydrates, besides chanical mixtures of all these in any proportion.

It would be impossible to prove what the condi were under which beds of pure salts like the Wyomin kali lakes were found, because the concentrations, pr tions and temperatures at the different stages of form are all unknown and it is evident that theoreticall same result could be obtained by many different reac Since none of the compounds are absolutely insolubl since nature has unlimited time and reagents, we mu gard any reaction as reversible, however completely i go in one direction in the laboratory. But it is not im ble that a consideration of the simpler reactions of factors may throw some light on the probable way in pure salt deposits have been formed. Starting with a tion such as our natural waters containing the bases um, magnesium and sodium and the acids carbonic phuric, and hydrochloric, the most insoluble compoun sible would be first precipitated. This is calcium carb or a mixture of calcium and magnesium carbonates fo beds of limestone or dolomite. Calcium carbonate is ever, much more soluble in the presence of other salts we usually think and magnesium carbonate is found in amounts in water of the state containing much sodiu bonate. The calcium sulphate would next be deposi the form of gypsum. Beds of gypsum of great thi exist in many parts of the state, as at Red Buttes, plaster of Paris has been made for many years, an abundant in most of the soils. In the Laramie Plain sum was found at intervals in boring the Universit sian well to the depth of a thousand feet. If, as is ge assumed, sodium was originally extracted from the in the form of carbonate, the absence of this salt in tate could be accounted for by the well known reaction een sodium carbonate and calcium sulphate to form m sulphate and limestone. This has been used in prac- agriculture on the advice of the California Station to nate the more injurious black alkali or carbonate. In of the state where sodium carbonate is found, as at n River and Johnstown, gypsum is of course absent, or y so.

If now we regard both the calcium and the carbonic as completely precipitated, we have left as possible ounds magnesium chloride and sulphate and sodium ide and sulphate. Of these, magnesium chloride is by he most soluble at ordinary temperatures and would fore be the last salt deposited and the first washed out an alkali bed. In all the alkali and waters analyzed in ate the sulphates are in large excess over the chlorides, may regard magnesium chloride as practically absent he salts formed would be only magnesium sulphate, m sulphate and sodium chloride. Analysis shows that st all of the alkali of the state consists of these three in varying proportions. There are beds of pure mag- m sulphate and sodium sulphate, but so far as I am there are no deposits of sodium chloride. Brines ex- t do not form beds.

hese three salts are about equal in solubility at ordi- temperatures and on complete evaporation would be ited together, which is usually the case. But their ve solubility is greatly changed by a variation in rature, as the sodium sulphate is much more soluble rm than in cold water, while with sodium chloride is little difference, so the fall in temperature in a sin- ght, which is often great in the arid region and high des, would precipitate a thick layer of crystallized sul- which would not dissolve again the next day. In

many of the strong alkali lakes this can be observed d
In cold weather the bottom is covered with a thi
of pure sodium sulphate, above which is a saturated s
containing much chloride. In warm weather part
bed goes into solution again. In winter Great Sal
throws up on the shore sodium sulphate crystals in
looking like snow drifts. The magnesium sulphat
might have been formed in a similar way.

It is possible by this system of simple reaction
plain the alkali deposits, although it is evident that t
be theoretically accounted for in other ways, and i
necessary to assume that similar deposits have an id
origin. All that is intended is to show how from a
solution of many substances, such as ordinary sp
river water, the salts actually found could be form
not the many others theoretically possible. It is no
sary to assume, as many have done, that the origina
corresponded in composition to the salts left in evap
of their leachings. With the conditions that prevail i
ming, an annual evaporation about five times as grea
rainfall, a porous soil and scanty vegetation, such
cumulation and differentiation of salts is quickly
plished. One can start with a good soil and irrigate
water of ordinary composition and in a few years cry
pure sodium sulphate may be picked off the surface
experiment has unfortunately been repeated on
many acres.

The principal source of the alkali is not, howe
water used in irrigation, but the beds of soluble sa
are deep in the soil. As soon as water is put on t
these salts are drawn to the surface by evaporatio
fact that the soils of the valleys are saturated wit
ought to be taken into consideration in the propose
lishment of reservoirs. If these are of wide ext

eat evaporation of these regions would concentrate the
ater and so increase the per cent of alkali it contains. To
is the alkali leached from the surrounding soil will be
ded and there is danger that water so stored would become
jurious rather than beneficial to the land which received it.

ABSORPTION OF WATER FROM ALKALI SOLUTIONS BY SEEDS.

Before we can hope to do much to mitigate the injuri-
s effects of alkali on plants we obviously must know what
at effect is. How does the alkali limit the plant? Al-
ough it will be many years before any complete answer
n be given to that question, yet the study of the subject by
e Station has cleared up some of the simpler points. For
e simplification of the problem it was divided into two
rts, the effect of alkali on the germination of the seed
d its effect on the growth of the plant. Only the first part
the work will be made public here.

The effect of alkali on the germination of seeds depends
three things, the kind of seed, the kind of alkali, and the
ncentration of the alkali solution. Sometimes the seeds
alkali solution are killed, sometimes they germinate but
ry slowly, sometimes they germinate more quickly as com-
red with those in pure water. The usual result is that
e seeds are delayed in germination for a long time. Now
Wyoming the season is too short anyway, and even a few
ys' delay will make the difference between a crop and a
lure.

A necessary preliminary to germination is the absorp-
n of water, and it seemed likely that the retarding effect
the alkali on the germination was due to its hindering the
d from absorbing the water it needed. Experiments
owed that this was the case, and work on this line has

been carried on in the chemical laboratory for about
years now. The technical details will be published i
annual report of July next, but a table showing the r
of one of the experiments is here given to show how
work is carried on. Wheat was the seed experimented
in this case and an equal weight of it was put into sol
of the common alkalies of various strengths, pure wate
a solution of sugar introduced for comparison. I
found that the absorption of water was influenced n
the kind of alkali or the strength of the solution but
by the osmotic pressure. Osmotic pressure is not gen
understood and in fact is a comparatively new conc
in science, but it is easy to explain what it means. I
case it simply means that the water passes throug
little coatings in the seed openings more easily than th
ticles of salt, and consequently a seed will take up
more rapidly if no salt is present. To give a rough ill
tion, a pump supplying city water works will get more
through the screen of the intake pipe if the holes
screen are not partly clogged with sand and drift
In this experiment, the solutions of sugar, sodium sul
magnesium sulphate, and sodium chloride were so m
to have the same osmotic pressure, and it will be see

Amount of Water Absorbed by Wheat from Salt Solution

No.	Solution of	Per cent of salt.	Osmotic pressure, atmospheres.	PER CENT WATER ABSORBED BY								
				12 hours.	24 hours.	36 hours	48 hours.	60 hours.	72 hours.	84 hours.	96 hours.	108 hours.
1.	Pure Water	0	0	331	426	492	516	546	557	583	601	601
2.	Sugar	1.43	1	334	432	493	513	543	552	582	598	608
4.	Magnesium sulphate	.34	1	314	401	463	493	521	547	567	577	596
6.	Sodium sulphate	.24	1	321	416	478	488	532	544	577	583	601
8.	Sodium chloride	.12	1	340	419	495	500	518	537	569	579	583
3.	Sugar	14.30	10	263	279	418	442	450	460	467	478	481
5.	Magnesium sulphate	3.94	10	312	384	433	455	456	469	479	489	489
7.	Sodium sulphate	2.66	10	297	383	436	440	451	459	463	479	483
10.	Sodium chloride	1.39	10	315	397	443	449	466	470	472	472	476

table that the wheat absorbed just about the same ount of water from each of these in the same length of e. Sodium carbonate ("black alkali") acts differently, when it is strong it attacks and destroys the seeds themes. Some seeds, too, give quite different results. Beans orb the same amount of water when put into a saturated tion of common salt as they do when put into pure wa- The dissolved salt apparently passes into the bean as lily as the water and destroys its power of germination. is intermediate between wheat and beans in this ret.

To decide the question whether the absorption of water hysical or physiological, comparative tests were made veen living seeds, and seeds in which the power of geration had been destroyed by age, heat, or exposure to ialdehyde vapor. No difference between the living and l seeds has been yet observed, so it appears that water rawn into the seed purely by such physical forces as sur- tension and osmotic pressure. It does not appear that salts mentioned, except sodium carbonate, exert any onous influence on the wheat. It germinates readily n removed from the alkali solutions and put under fable conditions.

The absorption of water is retarded and diminished by oresence of salts in the water, but not prevented. This e to the fact that the seed allows the salt to pass into it gh not so readily as the water. The volume of the led seed and the amount of salt they contain has been rmined and it appears that in strong solutions enough is absorbed to make the solution inside the seed nearly ame strength as that outside. In this way the resist- to absorption of water due to osmotic pressure is dished. The same means of obtaining water from a strong olution is probably used by such plants as the salt sage, h contains a large amount of mineral salts. This has

the double advantage of aiding the plant to draw
from the soil and to keep better what water it has, be
the salts dissolved in the sap lessen the evaporation.

The experimental work here outlined is being ap
to plants as well as seeds, with the hope of finding ou
it is that crtain plants thrive in soil containing much
and little water, while others, sometimes of the same g
will die under these conditions. Experiments on low
of life show that they can be made immune to the de
ous effects of a very great osmotic pressure by slow ch
and selection, and this suggests the possibility tha
same can be done for higher plants, and useful vegetat
grown to cover the acres now given over to greasewo
samphire.

Alkali Investigations.

B. C. BUFFUM.

FIELD EXPERIMENTS.

The experiments or lines of investigation under way in field were outlined in Bulletin No. 29 of this station. le it can not be said that any of this work has been com- d, some results have been obtained which are of inter- The productive area of the Station Farm is continually encroached upon by the rise of alkali salts on the lower of the land. At the same time the greatest care has exercised in our irrigation. It can not be laid to over- ation, or the careless handling of the water used. We of no way to effectually prevent the accumulation of i salts upon low lands which have no drainage outlet. possible to irrigate land which has considerable slope out allowing any appreciable amount of waste water to e, but, unless the land is level, some of the water finds ay through the soil or subsoil down the slope, carrying ntity of the soluble salts with it. If there is good drain- he salts are washed out of the soil into streams and d off. Where there is no outlet of this kind a reservoir med in which the salts accumulate just as water col- in a lake bed. As more of the salts are washed from the r ground the accumulation increases and more land is l to the unproductive alkali waste.

Vhere the process of leaching has not begun the salts ally occur distributed through the soil in comparatively small quantities. Small amounts of these salt beneficial, either acting directly as plant food or indir aiding in the process of plant nutrition. The fact tha soluble portion of our soils has not been leached out carried away by excessive rainfall accounts for such l being almost if not quite as rich and lasting as the soils a the Nile, which receive an annual supply of leaching sediment from the head waters of that stream. How when our lands are brought under irrigation and cultiv there seems to be no way of keeping the soluble salts tered through the soil as they were originally. When w is applied they move downward. By the percolation of w through the soil, the salts are carried from one place t other, accumulating where the water accumulates. W the water evaporates from the surface the salts in sol are left behind and more water coming up from below tinually adds its freight of salts, leaving them where can do the most damage to crops. This simple princip the movements of alkali salts in the soil along with the w furnishes the key to any preventive treatment which be along one of the following lines:

1. Irrigation with water free from salts.
2. Preventing seepage.
3. Draining the water from below.
4. Cultivating or treating the surface in such a w to prevent evaporation, which brings the salt to the sur

Over-irrigation and the lack of most intelligent thoughtful management brings about rapid and wide-sp destruction of the most fetile lands. Good natural or ficial drainage will enable the farmer who properly c cultivates, and irrigates his land to prevent any da from alkali, providing the water with which he irri does not bring large amounts of salts to his soil.[*] But are places without good, natural drainage where art nage will be too expensive for years to come and where li is accumulating more or less rapidly. As yet the er has no market for his crop of salts and unless he can reat the land that it will bring some return he is better without the useless acres upon which the taxes are the e as upon the rest of the farm.

---

[*] For data of the amount of alkali salts actually deposited upon some soils from t used in irrigation, see Wyoming Station Bulletin No. 24. "Water Analyses.")

All this discussion leads up to the point I wish to make. ough we may know of no easy or cheap method of reming such lands so all crops will thrive upon them we make them productive by introducing plants which will w in the presence of large amounts of alkali salts. Proor Hilgard has accomplished a great deal in introducing li resisting plants to cultivation in California. We have experimenting with such plants for some time and are able to report upon a few of them.

We have found very few useful plants which will grow re the soil contains so much alkali that an incrustation rmed on the surface. Incrustation of our ordinary white li on the surface is usually marked, at least during dry ther, where there is as much as one and one half or two ent of salts in the first two inches of soil. Such an unt of salts will prevent the growth of any of the cereals alfalfa. Barley and rye seem to stand more alkali than wheat or oats. I believe barley, rye, or alfalfa will grow e presence of as much as one percent of our ordinary e alkali, (sulphates of soda and magnesia), in two inches rface soil, providing the water level is not nearer the ace than two or three feet. Usually where there is so alkali as this, which has accumulated from irrigation e, the water comes near the surface, leaving the soil rated most of the time. Where this occurs less than one-of one percent of salt along with the water is fatal to crops. Upon soils containing about two percent of in the first two inches we have tried, without success, wheat, barley, oats, alfalfa, and Russian sunflowers.

Brome grass and red top have been partially successf
experiments with them have not been extensive en
reach final conclusions.

The following alkali-resisting plants need speci
tion.

SALT SAGES OR SALT BUSHES (Species of At

Just now many enterprising seedsmen are adv
the "Australian Salt Bush," (*Atriplex semibaccatum*),
farmers to purchase the seed for sowing upon thei
lands. It has been very successful in California, w
produces large yields of forage. However, it is a
climate plant and does not succeed in Wyoming. W
given it careful trials at Laramie, Lander, and Sherid
Laramie it only made a small growth the first seas
Sheridan its growth was thrifty the first summe
Superintendent of the Sheridan Farm, Mr. Lewis, stat
he had difficulty saving the plants from destruction b
he called "the common beet bug," or "the long gray
bug."* By a liberal use of Paris green, the insects w
stroyed. The plants made a spreading growth, almos
ing the ground by the time of frost. None of the plan
through the winter at any of the places they were tri

There are a number of species of atriplex, closely
to the Australian Salt Bush, found native in the Stat
grow in alkali lands. Some of them are of much imp
as forage plants. The more promising of these ar
studied by our Botanist, who is co-operating with
partment in attempting to introduce them into cul
and determine their value for wider distribution.†

---

*This insect is one of the Blister Beetles (*Epicauta sp. ?*). It has done consi
age to beets and potatoes in parts of the state, especially in Sheridan and Crook cou

†A valuable contribution to our knowledge of the forage plants which
alkali soils of our state is contained in Bulletin No. 13 of the Division of Agros
United States Department of Agriculture, entitled "The Red Desert of Wyoming
age Resources," written by Professor Aven Nelson of this Station. In this bull
sages and other plants found growing in alkali places are discussed, with data rel
value as food for range stock and suggestions as to usefulness of certain species if b
cultivation.

Plants of this character, which take up large amounts of e alkali salts, will naturally aid in removing the salt from e soil with the crop. Stockmen have long appreciated this operty of the salt sage, regularly making use of it as food r their range stock, to avoid the necessity of purchasing nmon salt for them.

ENGLISH RAPE.

Dwarf Essex Rape was planted upon the Experiment rm two seasons, being sown upon strong alkali soil which uld not produce grain or alfalfa. In 1894 a rather thin and was obtained. The soil was very damp all summer. out the first week in August the rape began to make a nk growth. When cut on September 3 it yielded at the e of a little over fourteen and one-half tons of green fodr per acre. In 1896 rape planted on strong alkali ground o made excellent growth. Rape is attracting much atten- n as a soiling crop or as forage, especially for sheep. hile it is an annual plant it may prove of value upon alkali ls in the state.

BOKHARA OR WHITE SWEET CLOVER.

(*Melilotus alba.*)

At Laramie and at Sheridan sweet clover has made large wth upon strong alkali soils. Unfortunately it seems to of little or no value unless it be as a honey plant for bees, ough I have been told it is cut and baled for cattle food in rts of Utah. Heretofore I have warned our farmers not plant this clover on account of its spreading to places ere not wanted and becoming a troblesome weed, where wed to ripen its seed.* Recent experiments indicate that nay be of some value for alkali land, to improve the soil ore planting other crops. In 1897 an alkali plat was

---

*See Wyoming Station Bulletin No. 16, page 236. In this connection Professor Hilgard ld me that in California, where sweet clover became a weed in wheat fields, millers refused the wheat, as it became tainted with the strong, peculiar odor of the clover seed and com- was made that the flour from such wheat made gingerbread. If planted for any purpose it not be allowed to spread, but all plants should be cut when in bloom to prevent the pro- n of seed. It is a biennial, producing its seed the second year and then dying.

planted to sweet clover. This season, 1898, at the time i
in blossom it had produced 18.4 tons of green tops per
and was plowed under for green manure. The av
height of the plants was 5.2 feet and computed as dr
the yield was over four and one-half tons per acre. I
difficult to plow under so large a crop. Like other leg
ous crops this clover takes nitrogen from the air by mea
the little tubercles on the roots. The roots of those p
which we examined were literally covered with these t
cles, which indicates that sweet clover may prove of val
a nitrifying agent. Adding nitrogen to the soil by the
combined with plowing under the rank growth of tops
prove the soil tilth and add humus, it is believed will
the land much more productive.

SUGAR BEETS.

Sugar beets thrive well upon soils strongly im
nated with alkali salts. It is claimed that excess of chl
in the soil upon which beets are grown, seriously inte
with the crystallization of the sugar in the process of
facture. This would give no trouble here as only
amounts of chlorides are present and the sulphates d
have the same effect.

As yet we have no sugar factories, but the beets
valuable as stock food.* Where fattening stock or
cows are to be fed during the winter, it will pay to
sugar beets to mix with other food. The beets may be
upon the alkali part of the farm, but in order to p
large yields the land should be fertilized the same
other soil upon which beets are to be grown.

In 1897 and 1898 we grew sugar beets upon soil
cally free from alkali, and upon soil containing so m
kali that ordinary crops would not grow. The co
tion of the alkali as shown by analysis made

---

*See Wyoming Station Bulletin No. 30, "Stock Feeding at Lander."

ield in the spring of 1897 was Sodium and Potassium
rides 14.39%, Sodum Sulphate 50.16%, Magnesium Sul-
20.03%, and Calcium Sulphate 15.41%. (Bulletin No.
228). The soil was not fertilized in either case and the
was much larger on the alkali soil. In 1897 the beets
analyzed by the U. S. Department of Agriculture, show-
large percent of sugar and high purity. The results are
in the following table:

Sugar Beets at Laramie.

Year.	Kind of Land.	Yield Per Acre, Pounds.	Sugar in Beet. Percent.	Purity
	Without alkali	11,643	19.0	89.2
	Strong alkali	14,486	19.7	88.1
	Without alkali	5,985	.....	...
	Strong alkali	12,632	17.5	...

RECLAMATION OF ALKALI SOILS.

The old saying that "an ounce of prevention is worth a
d of cure" is in place here. While it may be impossible
event the accumulation and rise of alkali on certain
ons of the farm, by taking the matter in hand early
me of land becoming unproductive may often be almost
initely posponed. The low ground where it is expected
i will first come to the surface should be kept in some
as alfalfa, which will shade the ground the greater
of the time, or planted to such crops as can be thor-
ly cultivated to loosen the surface and prevent evapora-

The only experiments we have made in reclaiming have
by open-ditch draining at Sheridan. In the summer of
one hundred and fifty rods of open ditch were dug to
about ten acres of the north-west corner of the farm.
oil of the farm is underlaid with hardpan and the leach-
of alkali from the higher land followed along this hard-
the lowest part, where the salts came to the surface.

A part of the time the water level was as high as, or the surface of the ground, and so much alkali collecte that even weeds which ordinarily thrive in the pres such salts would not grow. In 1896, one hundred and rods of additional ditch, two feet deep, was dug. The ing extracts from the annual reports of Superint Lewis since 1895 indicate with what success the ditch aided in reclaiming the land.

Extract from Report of 1895: "Our one hundr fifty rods of ditch made during the summer will, I prove a great benefit to the alkali land. The water d stand on the surface as it did."

Report of 1896: "Have made one hundred and rods of new ditch, connecting with ditch made durin which is doing much good in reclaiming the alkali lan

Report of 1897: "I consider our experiment wit ditches has done and will do a great amount of goo claiming the land. Land that has been a white, alkali bed for the last three years is now all covered heavy growth of weeds and grass, there being bu alkali which is apparent to the passer-by."

EFFECTS OF DIFFERENT ALKALI SALTS O SEED GERMINATION.

As a continuance of the laboratory work on se mination begun in 1896 and reported in Bulletin No. W. H. Fairfield planned and carried out quite an ex experiment to show the comparative effects of the d alkali salts. The credit for this experiment, the caref ner in which it was carried out and the full notes and tions of the results belong wholly to Mr. Fairfield, part of whose time was devoted to an enthusiastic s the matter in hand. The experiment was finished in of the present year and resulted in data of much inte ıe. In order to substantiate the results obtained, a part he experiment was repeated in November to check the ılts by bringing the seeds into contact with the alkali so- ons in a different way. The general results of the check so close to those in the original investigation that they to the same conclusions.

It is not our purpose here to make a full report of the eriment or a technical discussion of the results. There some points of interest and value to the general reader, ever, which we wish to note briefly. It is expected the report of the work with diagrams and tables will be pub- ed in the annual report.

Seeds of wheat and rye were germinated in pure water in solutions of carbonate of soda (black alkali), chloride oda (common salt), sulphate of soda (glauber salt), sul- e of magnesia (epsom salt), and in sugar syrups the ngth of which varied in the same percents as those of the s used. Each of the salts used and the sugar were ap- l to the seeds in strengths of one tenth of one percent, tenths of one percent, seven tenths of one percent, one, three, four, five, seven, and nine percent solutions. The r was used to throw light upon a technical point, which been suggested by Professor Slosson, whether the re- ng effect was due to the osmotic pressures exerted by ifferent salt solutions. The experiments show that this case and the fact throws much light upon the manner hich the injury to seed germination or plant growth place.

n these experiments it has been a most notable fact that amounts of alkali salts are beneficial or at least that accelerate instead of retard germination. No doubt amounts present in the soil also assist in the life of the , either stimulating its growth or acting directly as food.

The following table shows the amount of salt may be present without retarding the germination o and rye seeds. It is true that larger amounts than thi they retarded the germination the first few days, cau seed to germinate even faster than they did in wat the third to the fifth day, but in each case the total of seeds which would germinate was less than where was present.

	Magnesium Sulphate.		Sodium Sulphate.		Sodium Chloride.		Sodiu
	In Solution.	In Soil.	In Solution.	In Soil.	In Solution.	In Soil.	In Solutio
Wheat.. .	1 0	0.25	0.7	6 17	0 4	0.1	0
Rye . . .	1.0	0.25	0.7	0.17	0.4	0.1	0

The salts are injurious in the order they are this table. The black alkali (sodium carbonate) more injurious than the other salts, because it has a ing effect due to the fact that it is not a neutral salt acid is present to produce a share of the damage. salts composing our common white alkali magnes phate seems to be the least injurious, while comm (sodium chloride) is most injurious. Fortunately very little sodium cloride associated with the sulp soda and magnesia in our alkali. It should be explai the percent of salt in solution and the percent in the be very different under natural conditions. For there may be a large amount of dry salt present. is in solution it cannot effect the plant for the dry cannot enter the seed or plant and must remain ine in the presence of water, they are dissolved. The p salt in the soil given above is estimated upon the 24.5% of moisture being present. Thus, if th 2.20% of salt in the soil, if 24.5% of moisture were and dissolved all of this salt there would be a nine solution of salt to produce its effect upon the seed

It has been found that fewer seeds will live and it takes ger for them to germinate as the strength of the solution eases and there is a marked difference between the dif- nt salts.

Eighty-eight percent of the seeds of wheat germinated ater. In three percent solutions of the salts, amounting early three-fourths of one percent of salt in the soil the owing percent of the wheat was germinated: Mag- um sulphate, 86%, sodium sulphate 70%, sodium chloride , sodium carbonate 14%. Ninety-six percent of the rye minated in water. In three percent solutions of the salts following percent of rye germinated: Magnesium sul- te 92%, sodium sulphate 56%, sodium chloride 38%, sodi- carbonate 22%. This would indicate that rye will stand nger alkali than will wheat, which corresponds with our lts published in Bulletin No. 29.

In addition to the tests upon seed germination quite an nsive experiment was conducted with alkali in pots. ause of conditions which it was difficult to control, we not able to draw conclusions which would be authentic rding the effect of these salts upon the plant growth, the effect of the salt solutions upon the evaporation of r from soil is of interest. That alkali salts have an ap- iable effect upon the character of the soil (especially so e case of black alkali) was long ago pointed out by Pro- r Hilgard. Everyone who has given any attention to li soils has probably noticed that they appear damp, adjoining lands may seem perfectly dry. In the fol- ng table the number of cubic centimeters of water evap- d each day from pots of the same size and containing ame amount of soil, are given. The amounts given are ages of the amounts of water added each day for the ten days to take place of that lost by evaporation. For irst ten days there were no plants in the pots to tran-

spire water and change the result. There are many
larities in the table, probably due to difference in th
themselves, but the general result is the same. Fro
pots containing no alkali 17.7 c. c. were evaporate
day, while the amounts of water lost from those po
taining 9 % solutions (equivalent to 2.2% alkali in so
24.5% moisture) was approximately one half as muc

Influence of Alkali Salts on Evaporation of Water from Po

c. c. of water evaporated per day.

SALT.	Per-cent. 0	Per-cent. 0.1	Per. cent. 0.4	Per-cent. 0.7	Per-cent. 1.0	Per-cent. 2.0	Per-cent. 3.0	Per-cent. 4.0	Per-cent 5.0
	c. c.	c. c.	c. c.	c. c.	c. c.	c. c.	c. c.	c. c.	c. c.
Water lost in c c.	17.7								
Sodium Carbonate.	17.7	17.5	14.7	13.8	12.1	12.6	13.1	*8.2	10.3
Sodium Chloride.	17.7	15.4	14.1	14.0	12.3	10.9	9.7	9.5	7.9
Sodium Sulphate.	17.7	18.1	15.0	10.7	16.9	12.5	10.9	7 3	8.2
Magnesium Sulphate.	17 7	17.4	13.1	11.4	13.1	11.4	9.2	11.3	8.4
Sugar.	17.7	11.1	15.4	13.6	12.9	12.4	10.2	10.1	9.7

*Average for 9 days.

UNIVERSITY OF WYOMING.

Agricultural College Department.

YOMING EXPERIMENT STATION,

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JANUARY, 1899.

Trees of Wyoming and How to Know Them.

BY AVEN NELSON.

lletins will be sent free upon request. Address: Director Experiment
, Laramie, Wyo.

Wyoming Agricultural Experiment Station.

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THE TREES OF WYOMING
. . . AND . . .
HOW TO KNOW THEM.

AVEN NELSON.

INTEREST IN NATURE.

"In Nature's infinite book of secrecy,
A little I can read."—*Shakespeare.*

HOW DEVELOPED.—We are, as a matter of course, ifferent to individuals and subjects to which we are ngers. Personal interest *in* and love *for* a thing are result of intimate acquaintance with the worthy ob- . We *read* of love at first sight, but that affection makes us willing to serve and defend the one or the g that we cherish is evolved only through continued, ful association. No subject of human interest has n promoted or defended worthily except by those who e its friends because they had real knowledge of its th. The beauties of literature are evident to those who through intimate knowledge of it are prepared eel its power. Science is advanced by those who have prehended its aims and are thereby made its devotees. ire appeals with feeble voice to him who is a stranger er. A Thoreau, a Burroughs and a Lubbock were led in her opulent lap and there learned the secrets they so lovingly express.

THE CONDITION IN WYOMING.—In this fair state y of us seem to have been too busy to hold communion with Nature's visible forms. Because we lack k ledge concerning her we have been indifferent to he guage and her inspiring beauty. With the st aspects that present themselves in bleak, wind- plain, in the roaring blizzard, and in the beetling c mighty mountain we are all familiar. We are often ly strangers to her more lovely traits because thes velop outside the beaten paths. Yet some there ar have learned to know, and knowing have learned to her in her gentler moods:—have learned to know here beneath the bluest skies, softest breezes play fragrant flowers of rare beauty deck every hillside sweet streams murmur in every mountain valley many a crystal lake mirrors sky and shore; that en mosses occur in every shaded nook and lichens every rock and crag with gayest yellow and softest that stately trees crown many a hilltop and forests and dense clothe in solitude every mountain side.

We are rich in those elements of natural sc which appeal to the higher sentiments of our natur too often we are forced to live so apart from them we miss much of the good that ought to come to u that source. Three-fourths of the people of Wy live in towns upon the various lines of railroad. thirds of these towns are situated on the open and paratively barren plains. In some of these many first settlers thought of them simply as temporary of abode. This, added to the natural difficulties e tered in adorning the home and public grounds, le homes in desert-like places and our lives impove from a lack of those things to which our sentiments cling through all the passing years.

Who among us, of maturer years, does not recall ith interest or almost worshipful affection some stately ee, shaded lane or secluded forest nook of our child- ood's home? But there are towns in our state *today* ithout a tree or shrub or even a bit of lawn. Our chil- ren are missing that element of refinement which comes om beautiful surroundings outside the home. Girls and oys are nearing maturity in some localities in the state o whom any tree would be of interest and to whom a impse of a fruit tree in blossom would be as a glimpse to Paradise. There are homes in abundance where the ntiment expressed in the following lines would find no nswering chord:

> "Woodman spare that tree,
>   Touch not a single bow;
> In youth it sheltered me
>   And I'll protect it now."—*Morris.*

INCREASING INTEREST ELSEWHERE.—In many parts America, Nature has been so prodigal in the distribu- on of her trees that what we owe to them has been oorly appreciated. Just now, however, a great wave of terest and enthusiasm is sweeping over the country hich it is hoped will make trees and forests as cherished ere as they have been for centuries in the old world. hall not Wyoming have a part in this growing interest? hall we not learn something of the treasures of our hills d mountains? Shall we not bring into our lives and o the lives of our children some part of the enjoyment d help that comes to those who are in touch with Na- re? Sir John Lubbock says: "The love of nature is great gift, and if it is frozen out or crushed out, the aracter can hardly fail to suffer from the loss." If this true it would be well for us to remember that this ele-

II. "THE OLD HOME."

III. "THE NEW HOME."

TREES VS. TREELESSNESS.

t in our character, if it is to grow or even to live,
t have something to feed upon. We must surround
elves with those natural elements of beauty to which
sentiments can go out. These are prodigally abun-
in our mountains, but Nature has dealt less kindly
our great plains.

DEVELOPMENT OF INTEREST.—We must look before
an expect to see; we must see before we can know;
ıust know before our interest will be aroused; our in-
t must be aroused before we will exert ourselves to
g about the clothing of even our home grounds with
grandest elements of beauty in any lanescape—trees.

"No tree in all the grove but has its charms."—*Cowper.*

Knowledge brings interest, interest brings action.
o whom may we appeal to disseminate this know-
? Surely to all who have ever loved the trees of
ld home; to all whose children are growing to man-
or womanhood in any treeless town; to all whose
homes lie upon the wind-swept plains, and es-
lly to those into whose hands we are entrusting the
al training of our children. Yes, we can certainly
that our teachers will interest themselves in this
h of nature study that promises so much of good to
dividual pupils and to the community as a whole.

CASE IN POINT.—The early explorer who ven-
beyond the Missouri and the pioneer settler in what
Nebraska found the whole trans-Missouri region a
ss, wind-swept plain, the more western part at least
included in the hypothetical "Great American Des-
Little by little the boundaries of this desert are
cting and we may hope for its ultimate extinction.

Nebraska, recently the treeless state of the plains, is no longer treeless. Orchards here, shad there, and groves yonder meet the eye of the tra he is whirled across its broad acres. No longer eye follow the landscape until the gray of the und hills blends with the gray of the sky on the dista zon. Its transformation in one generation from treelessness to restful though animated homelikene be considered one of the achievements of the age. result is certainly one of the factors that have c uted to the greatness of our neighboring common

One of the most potent influences in bringin this desirable result has been the awakening of a sentiment, in regard to trees, the like of which where else in the United States been secured—and largely through the schools. The school touche home. Let the light of enthusiasm shine out teacher, then soon the whole school is ablaze with ness and the reflection extends even beyond the borhood bounds.

This sentiment for trees and enthusiasm f planting reached its climax in Nebraska in the ye mediately following the establishment of Arbor the suggestion of Hon. J. Sterling Morton. He gratefully remembered for that act long after hi public services have been forgotten, not only in N but in all the states where Arbor Day has become tablished institution—an institution the observ which is now all but universal.

Speed the day when interest in this subjec sweep over Wyoming, and, to hasten its coming, not hope to enlist the co-operation of all the t

hin our borders? Pupils and parents will alike be in-
ested in the trees of the state in their homes and in their
ation to ours. In what way can we better begin to de-
op this interest than by learning to know them? We
ll then soon find springing up a desire to enjoy, to own
to protect them.

FOREST RESERVATIONS.

> "I regard the forest as an heritage, given to us by Nature, not for spoil or to devastate, but to be wisely used, reverently honored, and carefully maintained. I regard the forest as a gift entrusted to us only for transient care during a short space of time, to be surrendered to posterity again as unimpaired property, with increased riches and augmented blessings, to pass as a sacred patrimony from generation to generation."—*Baron von Mueller*

The setting aside by the General Government of
ge tracts of forest lands, in various parts of the United
tes, to be preserved perpetually as forests, has met
h much favor in most parts of the country. Some crit-
m arose at first from a few who feared that private in-
ests might suffer or that certain industries, such as
ing, might be hindered in their development. Now,
fuller information has shown that the purpose of this
st legislation is wholly beneficent and that it is not
nded that these laws shall work a hardship on any
, even those who were at first inclined to criticise are
warm advocates of the policy. The early criticism
ves to have been a good thing. The attention of the
le country has been called to the great benefits we
ive from forest covered lands.

INFLUENCE OF FORESTS.—While this is not the
e for a discussion of this question, yet it may be well
nention a few of the points. First, it is well known
large, wooded areas exert a great influence upon the

climate of adjacent regions, i. e., temperature, mo and healthfulness are affected by them. Of greate portance, however, is their conservation of mo whether it falls in the form of rain or snow. T wooded summits and slopes of our mountains we ov fruitfulness of the valleys and plains below. The r taken up by the loose soil and leaves and sinks in crevices among the rocks. Days and even weeks by before it all finds its way into the brooks and str When it does reach these it literally filters into th clear and sparkling as if it had verily been distilled. snows of winter, protected in the shade of the woods and piled in great drifts in the canons, linger in the lap of summer, feeding slowly but surely the life giving streams upon which the vegetation in th ley and on the plain depends. It will easily be seen the forests hold back what would otherwise be floo ters in the streams that drain the region. So it ha that communities hundreds of miles from the great reservations are interested in their perpetuation.

Contrast the condition in open country or whe timber has all been removed. Rains that fall upon slopes run off with a rush, carrying the soil off wit water and washing out gullies, ravines and even ca In open regions we have seen the muddy streams flowing their banks after a shower or following the ing of the spring snows. The soil is all washed making worthless many a once valuable acre. The courses in such regions, during dry periods, inste being clear, flowing streams are little more than stag muddy pools.

Wyoming is fortunate in the possession of se vily forested mountain ranges. She is thrice blessed having within her boundaries three regions deemed thy of protection and preservation by our Government. us hope that these may remain to bless the people, h within and without our boundaries, through all time come. May national interest demand the preservan of the mighty forests that crown the summits and er the slopes of the Wind River mountains also.

Nature has further made amends for our wind-swept ins by giving us a fourth Forest Reserve, one in which whole world has an interest as the great Wonderland. is is the region where are conserved the waters that d the rivers of a continent. In Yellowstone Park are headwaters of three great river systems, the Missouri, Columbia and the Colorado, not to mention many ller streams that are ultimately tributary to these.

A PLEA FOR A PROTECTIVE POLICY.—Shall not we, itizens of the state which has most to gain, loyally supt a policy that means so much to our arid plains? Un- the past reckless management, or rather total want of ervision, enough timber has been destroyed by forest (often wantonly kindled) to bountifully supply the re state for centuries. Under a wise protective policy forests can be made to yield all the timber that we possibly use for domestic purposes, without in the t impairing their beauty, extent or productiveness. e learn to know our forest resources and their value s, then we shall come to appreciate them so highly we shall stand as a unit for their protection from e who would destroy them for private gain. We shall desire to protect them from the consequences of the ent reckless indifference that allows the destruction of thousands of acres of valuable timber by fire. V has not felt the desolateness of what would otherwise the most charming scenery were it not for the dead fallen trees that strew the blackened slopes. The wr has in mind two places in the state, making some pre sions as mountain summer resorts, which, with t limpid lakes, would have all the elements of natural be ty were not the whole effect marred by unsightly, bla ened stumps and progress impeded on every hand by tangled, fallen timber.

NAMES.

COMMON NAMES.—That it would be a most des ble thing to have a good expressive English name, only for our trees but for all the important plants, is fr admitted by all. In fact it seems so desirable that g effort is being made by those who think and write u these subjects to hit upon some good "common na upon which all can unite. The difficulties encounte however, are great, for not only do most plants have ferent common names in different localities but, wh worse, very different plants have the same common na To illustrate: One of our commonest trees, Lodge Pine, is also called in Wyoming, Tamarack and B Pine; in Utah, Prickly Pine; in Montana, White P in Colorado, Spruce Pine, and, possibly in other place yet other names. Then these names are also applie other trees, as, for instance, Tamarack to one other cies of Pine and to two different species of Larches possibly to other trees. How then shall we know tree is meant when we hear a name? No way sugg f except that we must, as a people, agree upon the expressive, available name. Then we must learn to that tree and must apply no other name to it and name must be applied to no other tree.

The names suggested in this bulletin are not original the writer but such are chosen from those in com- use as have secured the approval of men who have much time and thought to this subject.*

LATIN NAMES.—The scientific names have a great ntage in that only one name can properly be applied e plant in question and that the oldest one. By this the plant must be known the world over. Such a consists of two parts, the first or generic name h, in a way, corresponds to a person's family name he second or specific name which points out a par- r kind much as a given name points out a particular n. To illustrate: The Pines belong to the genus *s;* the Cottonwoods are *Populus.* To point out a cular kind (species) another word is added, as *Pinus is* (The Limber Pine) or *Populus balsamifera* (Balm lead). It is customary to add the name (or abbrevi- of it) of the person who first describes the species ings the right generic and specifis name together. the two just given should be written *Pinus flexilis* s, and *Populus balsamifera* Linn.

Now these Latin names are not so difficult to learn understand as most people imagine. They are in fact easily remembered than common names for they are descriptive of some character of the plant as may be in those given above.

Ir. George B. Sudworth in the excellent bulletins of the Division of Forestry, U. S. Agriculture is doing much to bring order out of the chaos of common names. I am cknowledge my indebtedness to Bull. No. 17 of that Div.

In the following pages the scientific name is pr in parenthesis, in italics, under the common name. hoped that those who really wish to know our tre the names now accepted for them everywhere will f arize themselves with these names in particular.

THE TREES OF THE STATE.*

TREE DEFINED.

Woody plants which continue to grow for some are known either as shrubs or trees. Size is usually the line of separation between the two but the f growth is quite as characteristic. The following definition seems to express the commonly accepte of a tree: "Trees are such woody plants as prod nature a single trunk, branching more or less abo ground."† Accepting this definition, there are in in the following list a few that are comparatively such as the Buffalo Berry and the Choke Cherry. even these have the true tree habit and may prope included.

***Special attention is called to Bulletin No. 38 by Pro Buffum, recently issued by this Station. That bulletin be title "The Cultivated Shade and Forest Trees," and consi detail the characteristics and relative value of the vario that are used on home and public grounds. Methods o planting and cultivating are also considered.**

Since native trees must be so largely used for dec purposes both on the home and public grounds it seems p that a bulletin on how to recognize them may be welcom this reason this bulletin is made to follow so closely, i that the two may supplement each other.

†Bull. No. 14, U. S. Dept. of Agriculture, Div. of Forestry.

KEY TO THE GENERA.*

Leaves needle-shaped:

†In small bundles of two to five....................1. Pine (*Pinus*).

††Singly and with sharp points....................2. Spruce (*Picea*).

†††Singly and with blunt points.....3. Douglas Spruce (*Pseudotsuga*).

Leaves short, scale like...........................4. Juniper (*Juniperus*).

Leaves with a true blade and stem (petiole):

†Fruit an egg shaped capsule, containing seeds furnished with a tuft of white, silky hair:

‡Buds resinous...................5. Cottonwood (*Populus*).

‡‡Buds not resinous......................6. Willow (*Salix*).

††Fruit a nut:

‡Small, in a close, cylindrical or oval cluster:

=Nutlet winged.................7. Birch (*Betula*).

= =Nutlet not winged.............8. Alder (*Alnus*).

‡‡Large, with a cup, singly or in clusters of 2 to 3.......
..................................9. Oak (*Quercus*).

†††Fruit with conspicuous wings:

‡Produced in pairs......................10. Maple (*Acer*).

‡‡Produced singly......................11. Ash (*Fraxinus*).

††††Fruit fleshy, drupe like (Stone fruits):

‡Seed single, large, flattened } 12 { Plum } (*Prunus*).
‡‡Seed single, small, round } 12 { Choke Cherry } (*Prunus*).

†††††Fruit fleshy, a pome:

‡Seeds large for the fruit, bony.......13. Haw (*Crataegus*).

††††††Fruit fleshy, berry-like:

‡Seeds several, small.......14. Serviceberry (*Amelanchier*).

‡‡Seed single, large, pulp dry....15. Silver Berry (*Eleagnus*).

‡‡‡Seed single, small, pulp juicy......................
....................16. Buffalo Berry (*Lepargyraea*).

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*The small number of genera and species of trees represented, it should be noted, does not ate a scarcity of trees nor the absence of forests. It simply indicates that the climatic conns on these high plains and mountain ranges are unsuited to any but the hardier forms. city of kinds does not mean scarcity of trees. One-sixth of the State or about 10,000,000 is more or less forest covered. Then too, what we lack in kinds of *trees* is more than made us in the wealth of species of ***shrubs*** and ***herbaceous vegetation***.

Pine Family.

(*Pinaceæ.*)

" The pine is the mother of legends."—*Lowell.*

This family of plants includes much the larger
the forest trees of Wyoming. Those belonging in
families are either small and scattering or form
fringes on the stream banks—scarcely, if ever,
body of timber. The Pine Family, though far from
confined to mountainous countries and cold clim
peculiarly characteristic of such regions. The g
development and largest number of species occur
ever, where a moderately cool temperature is com
with an abundance of moisture, as is the case o
portions of the Pacific coast. Of the sixty species
become trees, credited to Northwest America, only
are positively known to the writer as occurring with
bounds.

This family has for a long time been known
Cone-Bearers (*Coniferæ*), since the fruit of mos
members is somewhat cone-shaped.

The cone consists of a number of spirally ar
scales on which the naked seeds are borne. All th
of this group are more or less resinous and are al
green. The four following genera, with the species
each, constitute the tree-like representatives of th
ily in this state.

1. PINES.

(*Pinus.*)

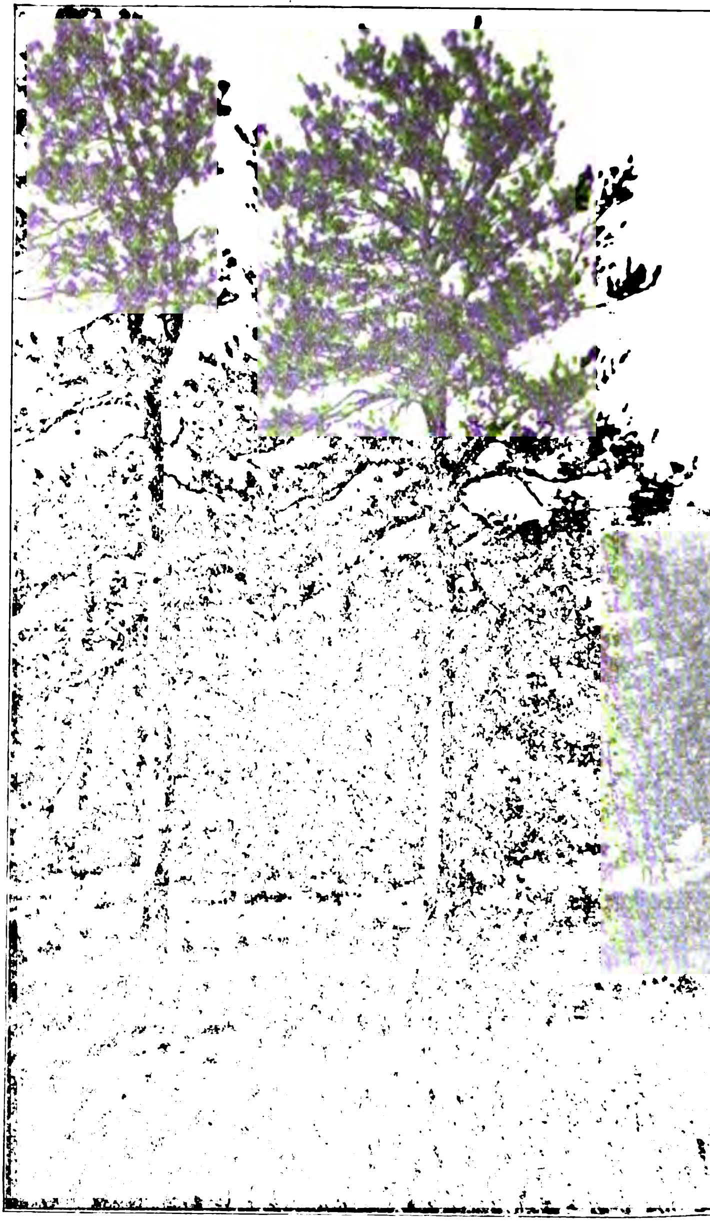
> **" Ancient pines,**
> **Ye bear no record of the years of man,**
> **Spring is your sole historian."—*Bayard Taylor.***

The term pine is by most people applied very loosely. ple, ordinarily well informed upon other subjects, ut- y fail to discriminate between the most widely differ- cone-bearing trees. To most they are all simply eautiful pine trees," whether they are Pines, Spruces, s, or more widely divergent forms. Even Junipers are etimes included in this convenient term. To separ- them is so simple a matter that our attention need be ed to only a very few facts to enable us all to call a a pine, and a spruce a spruce, the moment that we them. That both of them belong to the Pine Family d not mislead us, for it is common practice to use in name of a family of plants the name of the principal us in that family. A family may have many genera well marked characters.

How to Know Pines.*—Leaves in bundles of two ve (see illustrations); cones rather large and heavy, es tough and woody; seeds borne on the base of the es.

Three species occur, as follows:

Those who have occasion to use this Bulletin will please note that all statements and de- ns have reference to Wyoming trees. No effort has been made to discriminate except our own species. The aim, ready reference, is best attained by few words. Full char- tions would hide the species in a mass of botanical terms.



IV. ROCK PINE. *Characteristic trees, 75 to 100 feet in height.*

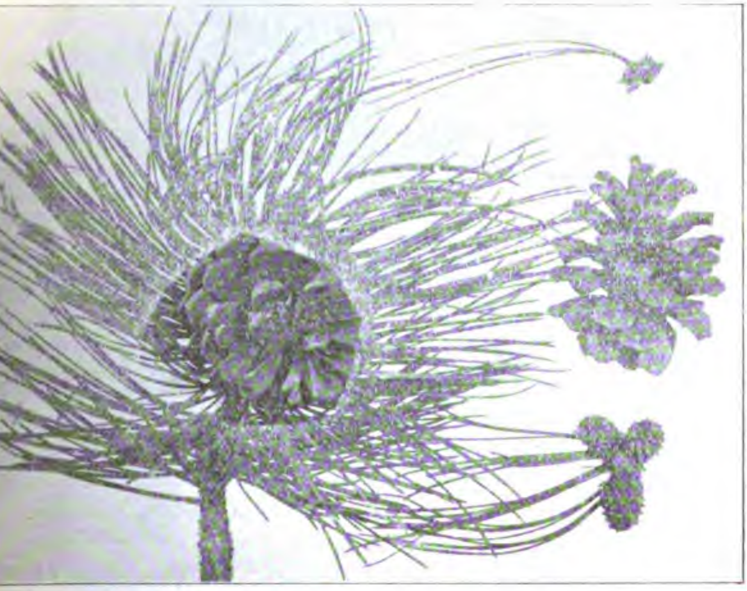
(1) ROCK PINE.

(*Piuus scopulorum* (Engelm.) Lemmon).

> "Under the Yellow Pines I house,
> When sunshine makes them all sweet scented,
> An' hear among their furry boughs
> The baskin' west-wind purr contented."—*Lowell.*

Description.—Leaves in bundles of three (rarely two), 4 to 7 inches
, slightly rough on the margins; cone 3 to 5 inches long, scales much
kened at the outer end and bearing a sharp, recurved prickle.

This is one of the largest trees of this state, attain-
a height of 75 to 125 feet and becoming 3 to 5 feet in



V. ROCK PINE. *Young and old cones and leaf-bundle.*

meter. In some localities, however, as at Pine Bluffs
in the Dakota Black Hills, only comparatively young
s seem to be present. It is probably the hardiest and
t widely distributed, though not the most abundant.

It occurs in all of our mountain ranges from the foo
up to about 8,000 feet. The wood of this pine is h
and resinous, with a handsome grain. It is used to a
siderable extent for domestic and commercial purp
The tree may always be known by its stout, usually

VI. LIMBER PINE. *The Pine of the wind-swept slopes and hilltops.*

habit; well formed trunk; the long needles (leaves)
grow brush-like on the ends of the stems, and b
thickened, spine-tipped scales of the heavy cones.
names we often hear, Pitch Pine and Yellow Pine,
distinguish it, for there are some others bearing
names.

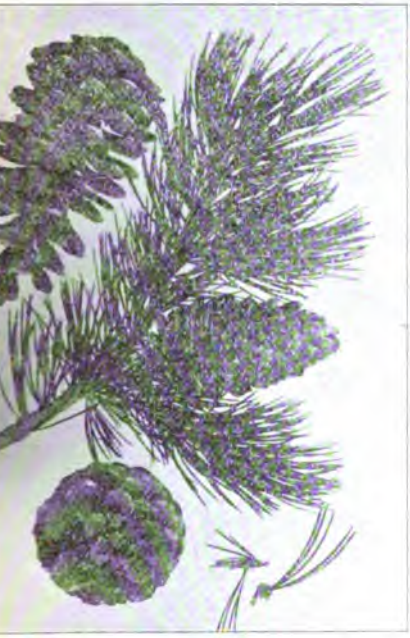
(2) LIMBER PINE.

(*Pinus flexilis* James).

"In winter, when the dismal rain
Came down in slanting lines
And Wind, that grand old harper, smote
His thunder-harp of pines."—*Alex. Smith.*

Description.—Leaves five in a bundle, 1½ to 2½ inches long; cones ht colored, long egg shaped, 3 to 4 inches, their scales with broad tips, not ch thickened, widely spreading when mature.

Like the preceding, this is widely distributed and oc- rs in the hills and mountains in the most exposed situations. It forms a scattering growth or more rarely a continuous forest; is usually most abundant on east slopes, and is found at somewhat higher elevations than the preceding. It is rarely a well formed tree, except when it forms a dense forest, on account of the stress of weather that it has to endure in the exposed situations which it occupies. Its remarkably limber twigs, which no weight of winter snow can ever ıp, enable it to withstand the fiercest tempest. far as our species are concerned, the five-leaved ndles and unarmed cones will at once distinguish



II. Limber Pine. *Cones, twig and leaf-bundle.*

VIII. **LODGEPOLE PINE.** *A characteristic forest of this species.*

It is largely used for fuel and possibly for other dostic purposes.

(3) LODGEPOLE PINE.

(*Pinus Murrayana* "Oreg. Com.")

"Silent sea of pines."—*Coleridge.*

Description.—Leaves in bundles of two, about 2 inches long; cones l, reflexed, adhering tenaciously to the branches, which are often marked he dead, persistent cones of the previous years; scales in the cone com- , the thickened, quadrangular ends tipped with delicate recurved prickles.

The most abundant of our pines. It usually occurs arge tracts as a dense forest and is found in all of our mountain ranges, especially on the moister slopes and where the winter snows are abundant. It prefers middle elevations, 6,000 to 9,000 feet. When growing in dense tracts it is exceedingly slender for its height and no doubt was formerly the source from which the Indian secured the light, slender poles for his wigwam. Poles 40 to 50 feet in length a man may very easily carry. When the trees are scattering they become pole-like and attain a diameter of a foot or more. species has furnished in Wyoming much the larger of the poles for the miles and miles of fences. The

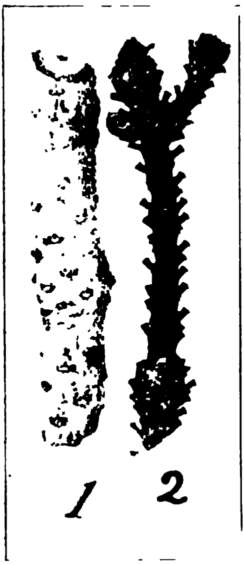
Lodgepole Pine. *Cones, twig and leaf bundle.*

dead poles in a burned district can be prepared with little labor as they are nearly free from branches. Some lumber, railroad ties and much of the "lagging" for mines are obtained from this pine. This species is readily known by its slender habit; its persistent cones, and its paired leaves.

2. SPRUCE.

(*Picea.*)

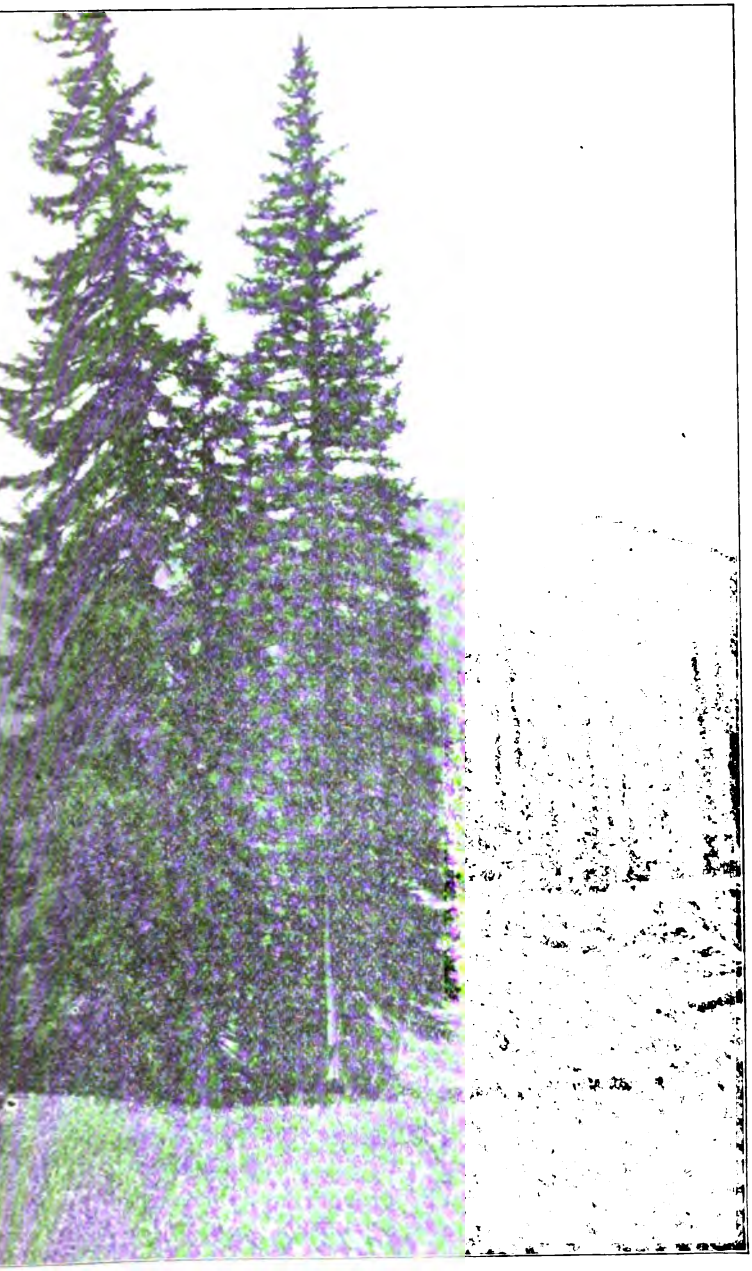
"This is the forest primeval."—*Longfellow.*



X. Spruce twigs, showing the manner in which the leaves are detached.
1. Douglas Spruce.
2. The true Spruces.

There are three trees in the state that are properly known as Spruces. Two of these may be known as *true* Spruces (*Picea*) and the third is the Douglas Spruce, which is placed by itself in the following genus (*Pseudotsuga*). All Spruces are at once separated from the Pines by the arrangement of the leaves—in bundles in the Pines, singly in Spruces. They are also easily separated by the cones—heavy with thickened scales in the Pines, light with thin scales in the Spruces.

The *true* Spruces are to be distinguished from the Douglas Spruce by the way in which the leaves are detached from the branchlets. In the former when the leaves fall away the branchlets are rough with the projecting, persistent leaf-bases; in the latter the branchlets are smooth, marked



NGELMANN SPRUCE. *Characteristic trees. This species often forms a close forest.*

only by the oval scars of the fallen leaves. The accompanying figure will make this plain.

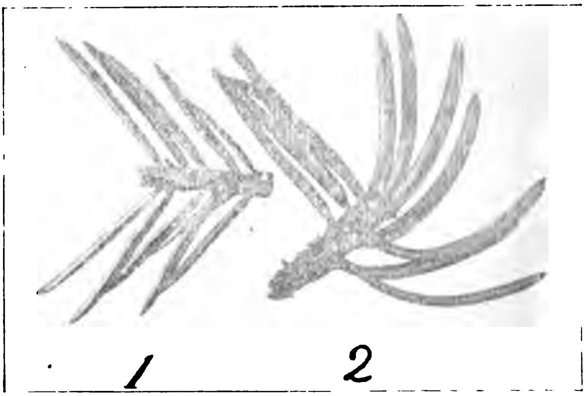
(1) ENGELMANN SPRUCE.

(*Picea Engelmanni* Engelm.)

"Grove nods to grove."—*Pope.*

Description.—Leaves from ½ to 1 inch in length, singly and somewhat uniformly distributed upon the branches, four-angled, abruptly sharp pointed; cones oval or oblong, about 2 inches long and half as thick; scales thin, tough, ovate, with a square-cut tip which is entire or may bear a few small teeth.

This is the most important forest tree in the state. Hundreds of square miles in our higher mountains are completely clothed with it. Though not the largest of our trees, yet it attains in favorable situations a great size, becoming perhaps 100 feet in height and two feet or more in diameter. It is rarely found much below 9,000 feet and from that altitude up to timber-line it is usually the only species. At the upper limit of trees it becomes merely a spreading, prostrate shrub, buried for months beneath the load of the winter snows. These are strikingly different in appearance from the tall, spire-shaped trees on the lower slopes.



XII. Leaves of the true Spruces. *1. Blue. 2. Engelmann.*

From this species is obtained much of the native lum- r that is produced in the state. The wood is firm and stic and while it is difficult to obtain lumber free from ots, yet since these rarely fall out, it has been found table for a large number of purposes.

This is the species that the Forest Reserves are es- cially designed to protect. These great tracts of sub- ine woods hold back the waters of the winter snows, m which the streams are fed late into the summer nths.

(2) BLUE SPRUCE.

(*Picea pungens* Engelm.)

"No tree in all the grove but has its charms,
Though each its hue peculiar."—*Cowper.*

XIII. Blue Spruce. *Twigs and cones.*

Description.—Leaves very similar to the preceding, more slender and rigid, more strongly 4-angled and sharper pointed, often with a blue-green (glaucus) color; cones also quite similar (reddish-brown in both), longer and more cylindrical in this, scales very thin and usually with a wavy, irregular edge.

The Blue Spruce, while widely distributed throughout the Rocky Mountains, cannot be said to be abundant. It occurs at intervals throughout our mountains, mostly as scattering individuals or in small clumps. It is found at middle elevations, rarely reach- 9,000 feet, and prefers moist soil. Near streams and on moist slopes it makes a fair-sized tree, but the wood is said to have little value.

It is not readily distinguished from the preceding except by its habitat, its usually smaller size, its cone-shaped habit, i. e., its sharply tapering crown, and its blue-green or silvery foliage.

On account of its handsome appearance it is largely used as an ornamental tree for planting on the home or public grounds.* Most of the trees thus used are nursery grown, as they transplant more readily than those removed directly from their mountain habitat.

There is a probability that Wyoming possesses one of the true Fir trees. Though the writer has not found it, he has no reason for thinking that the species that has been reported a few times from our higher mountains is not here. Sometimes such reports arise from mistaken identity, but in this case it will be rather surprising if the presence of the following species is not established:

ALPINE FIR (*Abies lasiocarpa* (Hook.) Nutt.) A slender tree of the higher mountains of the western United States. Its leaves, like those of the Spruce, are borne singly, somewhat in two ranks: the branches are arranged in a succession of whorls: the cones are nearly cylindrical, about 2½ inches long, erect and produced at the sides of the branches: bark thin and pale. If any of the users of this bulletin happen to find this tree, the foregoing statements will aid in distinguishing it from the Spruces, the only trees in this state with which this Fir could be confused. Reports concerning it will be welcome.

3. DOUGLAS SPRUCE.

(*Pseudotsuga taxifolia* (Lam.) Britt.)

"Oh! proudly then the forest kings
Their banners lift o'er vale and mount."—*Edith May.*

Description.—Leaves flattened, with a narrowed, stem-like base, mostly blunt pointed, whitish below, twisting on the base so as to appear comb-like on the branches, ¾ in. to twice that length: cones egg shaped, about 3 inches long and half as thick; three pointed bracts project from among the scales of the cone: bark, in old trees, very thick and furrowed.

This is one of the largest trees of the state and for that matter of the United States. It reaches its maximum size in moister climates, but even here it is a stately e, often much exceeding a hundred feet in height. It curs in canons and on rocky slopes up to 10,000 feet, finest specimens being found near the banks of moun- n streamlets. Its wood is hard and durable, making it much value where heavy timbers are required. Much nber is made from it and for railroad ties it is consid- d superior.

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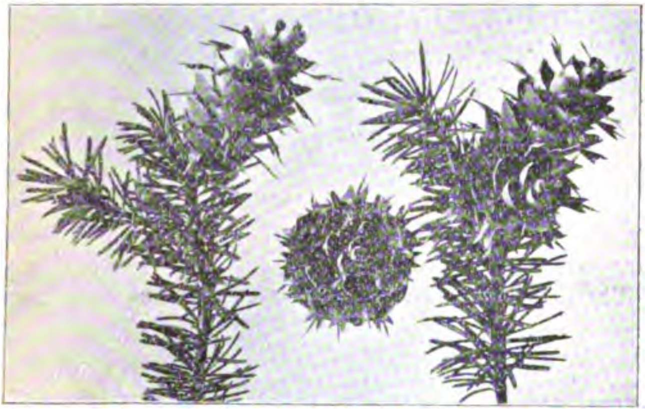
*See Bull. 38 of this Station by Prof. B. C. Buffum.



XV. Douglas Spruce. *Twigs and mature cones.*

It may always be distinguished from the true Spruces its blunt leaves, its thick, furrowed bark, and especial- y the cones. These, with their three-pointed bracts, quite peculiar to this tree.

4. JUNIPERS.

(*Juniperus.*)

"Thus yields the cedar to the axe's edge,
Whose arms gave shelter to the princely eagle."—*Henry VI.*

The members of this genus are often known as *cedars*, this name properly belongs to another genus, while this group should always be called *Juniper*. Of the twelve tree-like Junipers in the United States, Wyoming has two, both of which have recently been described as new. One of these has been known for years as occurring here, but has been supposed to be the same as the Red Juniper of the eastern states. It was only in 1897 that the distinctions between the two were made out, in part from a series of specimens prepared at the University of Wyoming for Dr. Sargent, Director of Arnold Arboretum. It now bears the name first given below. The other species, the second given below, seems to have been overlooked until named and described by the writer in 1898. This does not mean that it is particularly scarce in its locality but only that, though observed by many, it had been assumed, as with the other, to be one of the well known species.

Though the Junipers are included in the cone-bearers yet the cone will hardly be recognized as such. The scales are small, few and fleshy and form a small globose berry instead of the ordinary cone. This, with the fact that the leaves* are scarcely more than short, fleshy scales, will enable anyone to at once recognize these evergreen trees, our two species of which it will not be hard to separate.

(1) ROCKY MOUNTAIN JUNIPER.

(*Juniperus scopulorum* Sargent).

> "Will these moss'd trees,
> That have outliv'd the eagle, page thy heels,
> And skip when thou point'st out?"—*Shakespeare.*

Description.—Leaves in pairs, very short, nearly clothing the branchlets: berries very numerous, not maturing until the close of the second season, light green when young, when mature blue with a whitish bloom.

This species is found at intervals throughout the state from the southeastern to the northwestern corner. It occurs in canons and on rocky bluffs. Often it is stunted and shrublike but more often a tree with short, thick trunk and rounded top. Sometimes it branches from the base and then resembles in habit the following species. Its wood, though occasion-

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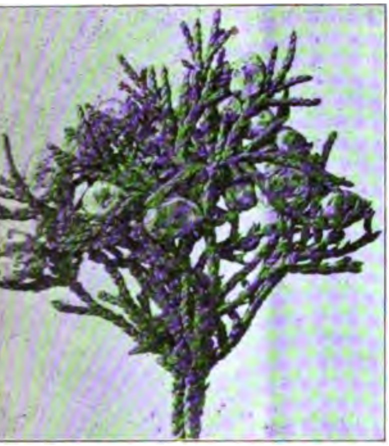
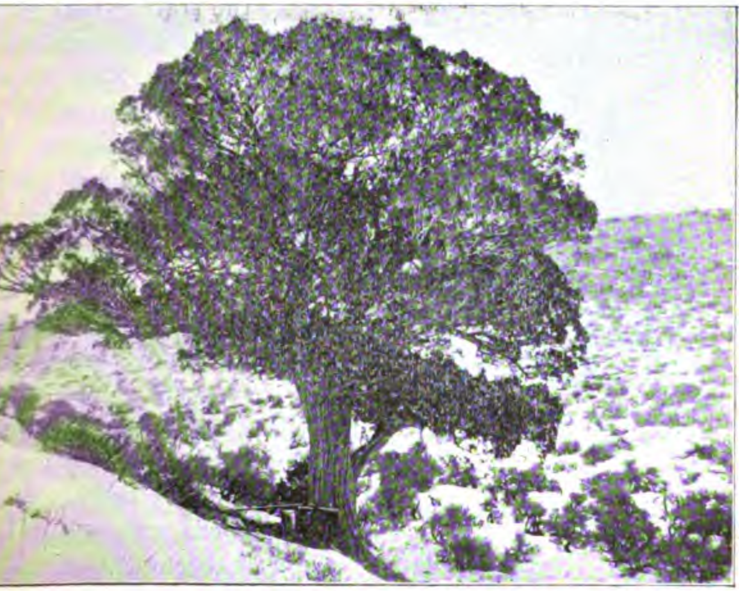
*In very young plants the leaves are usually longer, needle or awl shaped, sometimes ½ inch in length.



Rocky Mountain Juniper. *The tip of a branch, showing berries.*



. **ROCKY MOUNTAIN JUNIPER.** *Usual form, but often more shrubby and branched from the base.*

ally used for fuel, is particularly valuable for posts, as it resists decay to a remarkable degree even when in contact with the soil. Its habit, its numerous small, blue berries, which have a whitish bloom, and its slender twigs will serve to separate it from the next.

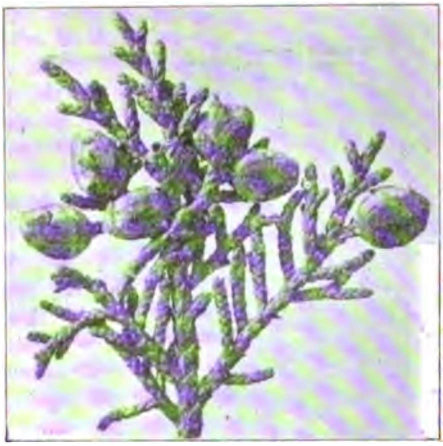
(2) DESERT JUNIPER.

(*Juniperus Knighti* Aven Nelson)

> "The century-living crow,
> Whose birth was in their tops, grew old and died
> Among their branches."—*Bryant*.

Description.—Branched from the base, rarely with a single trunk, usually a rounded, bushy clump of sub-equal trunks and spreading branches, 10 to 30 feet high: leaves three-ranked, thick, about 1-12 inch long; berry blue-green or copper-colored, marked on the surface by more or less projecting points: seed single (rarely two), large, covered by the dry pulp.

So far as the distribution of this tree is known it is confined to the south-central and the southwestern part of the state. It occurs in those desert portions, like the Red Desert, from which all other trees are absent. Even here it occurs only at intervals on the red sandstone hills and bluffs as scattering individuals or sometimes forming considerable thickets. It will be known by its bushy habit, its thick twigs and its large, roughened, copper-colored berries. In the localities where it occurs it furnishes fence posts and fuel.



XVIII. Desert Juniper. *The tip of a branch, showing berries.*

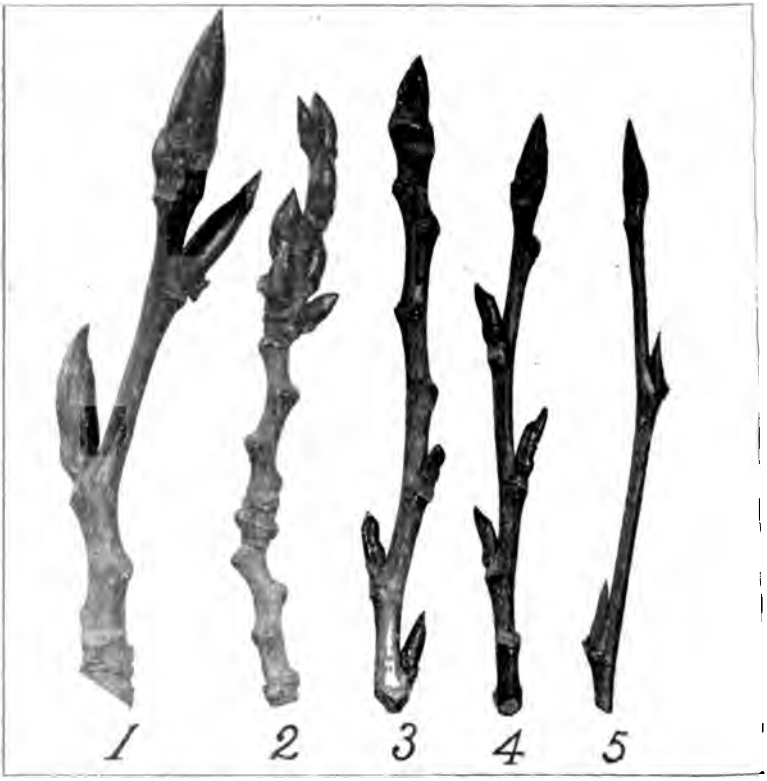
XIX. DESERT JUNIPER. *Typical specimens of this species.*

Willow Family.

(*Salicaceæ*)

Although Cottonwoods and Willows seem quite dif-
ent, yet, botanically, they have many features in com-
n. Both drop their leaves at the end of the growing
son, that is they are deciduous. Both have the male
d the female flowers on different trees (dioecious). The
vers in both are produced in early spring, before or
h the leaves. Male and female flowers are both in
nder clusters or tassels known as *aments* or *catkins*
e "pussies" of the children). These are usually droop-

ing in our Cottonwoods but mostly erect in the Willows. The female flower cluster develops into a somewhat similar but more elongated cluster of capsule-like fruits, which are two-celled and contain several small seeds that are furnished with a tuft of fine hairs. When mature these are readily borne for miles by the wind, but only a very small percentage are ever lodged in a suitable place for germination and development.



XX. COTTONWOODS. *Twigs showing characteristic winter buds. 1. Balm of Gilead. 2. Aspen. 3. (Common) Cottonwood. 4. Lanceleaf Cottonwood. 5. Narrowleaf Cottonwood.*

5. COTTONWOOD.

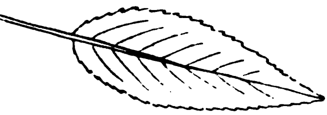
(*Populus*)

"He that plants trees loves others beside himself."

The Cottonwoods need no description as a group: hey are known to everyone, but it may not be perfectly ear that the Aspen and the Balm of Gilead are Cotton-oods. In fact we shall not call them by that "common ame," but they as well as the other three belong in the enus *Populus*. Our five species are easily known in the mmer time by the shapes of the leaves, as shown in the gures accompanying the short descriptions below. Since ese are the trees that we must use to a large extent for ade and ornamental planting* in this state, it is desira-e that we be able to recognize them in their winter con-tion also. Transplanting can most safely be done in e spring before the buds open. To assist in recogniz-g them at that time the accompanying plate, showing a ig and buds of each, will be helpful, as will also a study the bark character.

(1) NARROWLEAF COTTONWOOD.

(*Populus angustifolia* James)



Description.—Leaves small, oblong or lance-shaped, usually acute at the apex and with rounded base, finely scalloped on the margins: buds small, pointed, dark brown (see Plate XX, Fig. 5): bark thick, coarsely furrowed dark colored, these characters more pronounced as the tree grows older.

The most abundant of the Cottonwoods (excepting Aspen) in this state. It becomes in some localities a ge tree, sometimes 75 feet high and 3 feet in diameter, ugh usually it is much smaller. It occurs at intervals all the larger streams in the state either as a fringe on their borders or in groves quite covering the adjacent low bottom lands. It may always be known by the small, narrow leaves and the dark, thickened, furrowed bark which becomes enormously thickened in the old trees.

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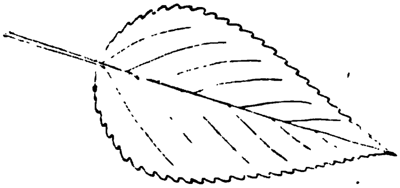
*See Bull. 38 of this Station.

(2) LANCELEAF COTTONWOOD.

(*Populus acuminata* Rydb.)

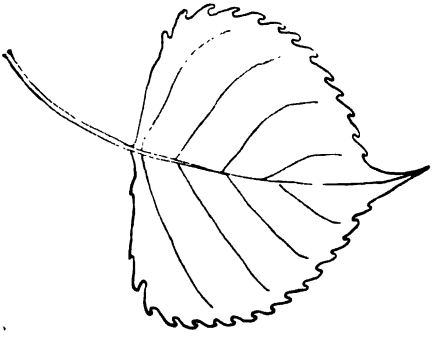


Description.—Leaves broadly lance-shaped or ovate, apex acuminate, finely scalloped on the margins, larger than in the foregoing species, 2 to 3 inches long (on young shoots often more): buds medium sized, light brown (see Plate XX, Fig. 4): twigs slender, light colored: bark in young trees very smooth and almost white, becoming darker and rougher as the trees get older but never so much so as in the preceding species.

Though found native in the state it is far from common and, so far as the writer's observation goes, occurs very sparingly on only a few tributaries of the Platte in the eastern part of the state. That it occurs elsewhere within our borders is, however, quite probable. It attains nearly as great a size as the preceding but is a smoother, handsomer tree at all times. It makes a more rapid growth, is a trifle less hardy but is used largely for planting—mostly from nursery stock.

(3) COTTONWOOD.

(*Populus deltoides* Marsh.)



Description.—Leaves broad, deltoid-ovate, the apex abruptly pointed, the base nearly truncate, rather coarsely scalloped or toothed on the margin: buds larger than in the preceding (see Plate XX, Fig 3): the youngest branchlets angled: bark grayish, becoming rough and irregularly furrowed as the tree gets older.

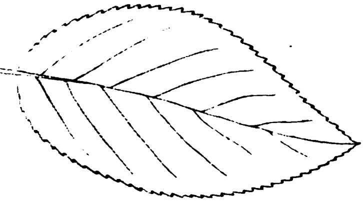
This is the (common) Cottonwood of

e eastern and central United States. Throughout that gion it is very abundant but it just comes into our range the eastern border of the state. On the Platte and its ibutaries and in Crook and Weston counties it is known occur. It is the largest of the Cottonwoods and may sily be known by its leaves and the "necklace-like" uits as well as by the bark which is roughened by lique furrows, and is nearly uniform in color through- t.

Like the preceding it is used to some extent for fuel d other domestic purposes but the wood is soft and eak and not very highly valued.

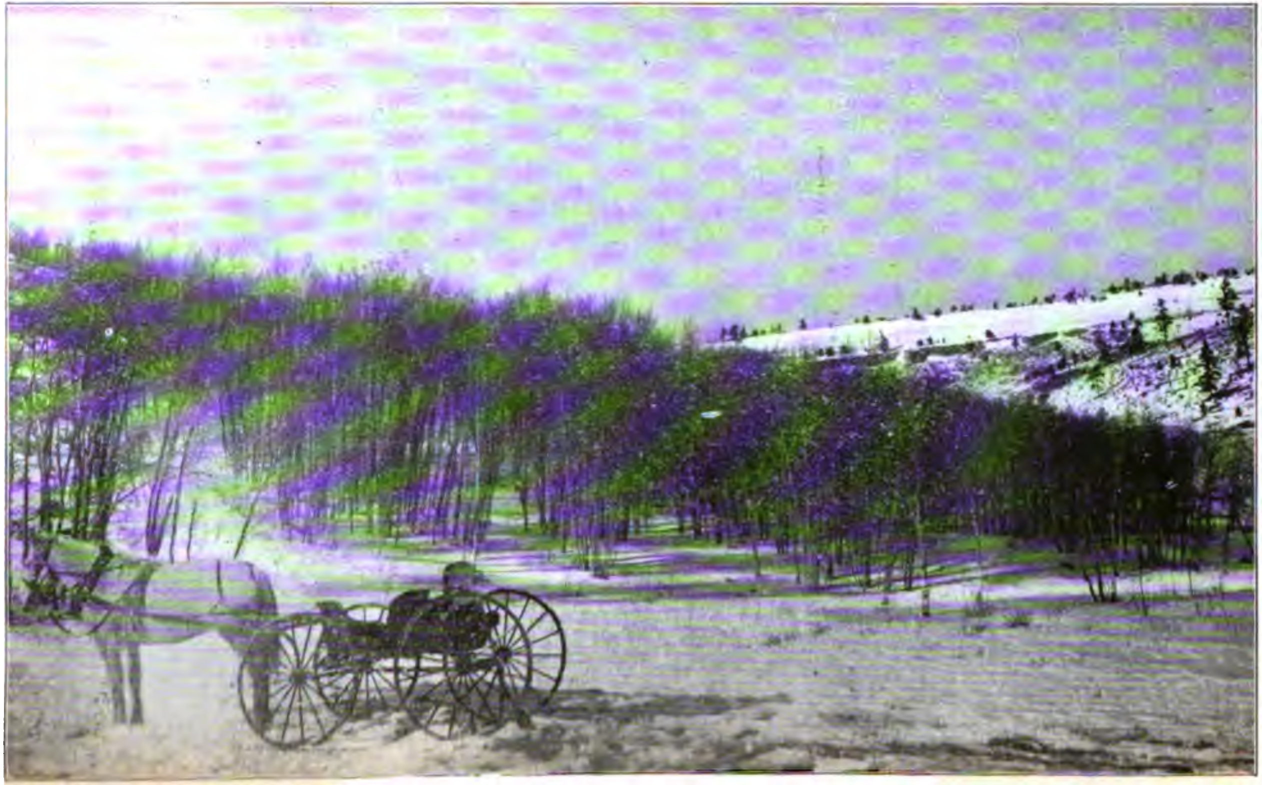
(4) BALM OF GILEAD.

(*Populus balsamifera* Linn.)



Description.—Leaves ovate, tapering gradually to the acute apex, smooth and green above, whitish beneath, finely scalloped on the margins: buds large, coated with resinous, glutinous gum (see Plate XX, Fig. 1): bark smooth on young trees, somewhat roughened on the old, darker in color than in the Lanceleaf Cottonwood which also has nearly smooth bark.

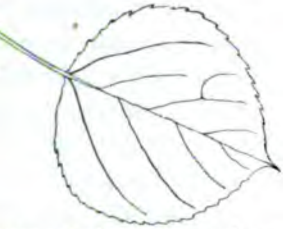
This species is of rather rare occurence in Wyoming. range is eastward and northward in the United States d Canada where, in favorable situations, it attains a large e. It seeks sheltered localities on the banks of small es and streams. It may be expected in such situations all parts of this state, though it is never found in abunnce—usually scattering trees or small groves only. With it has little economic importance except as a shade or namental tree. Its large resinous buds, leaves shiny ove and whitish beneath, and bark comparatively smooth l enable anyone to know this tree.



XXI. AN ASPEN GROVE. *Characteristic location among the hills.*

(5) ASPEN.

(*Populus tremuloides* Michx.)



Description.—Leaves small, broadly ovate or rounded, abruptly short pointed, finely toothed on the margins, leafstalks flattened latterally causing them to tremble in the slightest breeze: buds short and thickened (see Plate XX, Fig. 2): somewhat crowded at the ends of the twigs: bark smooth except in very old trees.

Found in abundance in those rts of the state where hills or mountains abound. It curs as thickets or groves on the slopes where snow-ifts form and on the banks of mountain streams. Our ustration shows a characteristic location and a typical spen grove. The trees are usually small but in very vorable situations may attain a height of 50 feet or ore.

The long, slender, pole-like trunks are used more or ss for fencing, and as fuel are not to be despised. ansplanted from the grove and set out singly they ow but slowly and never form shapely trees.

6. WILLOW.

(*Salix*)

Perhaps no other state in the United States possesses many different kinds of willows as Wyoming. Mr. M. Bebb (now deceased), the greatest authority on wil- vs in recent times, in a letter to the writer a few years ce emphasized "Willow State" as a suitable name for yoming. In spite of the large number of species found hin our borders we have very few that attain tree-like e. Most of them are mere shrubs, forming great thickets on the borders of our mountain brooks and swamps and fringes on the banks of the larger streams. The few merely named below do, however, attain the stature of small trees. No attempt will be made to characterize these as it would require more space and fuller botanical descriptions than this bulletin contemplates.* Everyone knows a willow, knows where willows are to be sought and knows, too, something of their uses. The following are the species that may be included among the trees of the state:

(1) ALMONDLEAF WILLOW.

(*Salix amygdaloides* Anders.)

One of our largest and most widely distributed tree-like willows. It is generally spoken of simply as the "common willow."

(2) WESTERN BLACK WILLOW.

(*Salix lasiandra* Benth.)

The Wyoming form of this willow is considered only a variety (var. *caudata*) of the species as written above. It ranks with the preceding in size and is widely distribted in the state.

(3) BEBB WILLOW.

(*Salix Bebbiana* Sargent)

Though never large it is decidedly tree-like on account of its usually single trunk and rounded bushy top.

It seems doubtful whether any of the other numerous species attain such a size as to be called trees.

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*Possibly sometime in the future it may seem of sufficient importance to issue a special bulletin on our Willows and their uses. The entire list and the means of recognizing them may then be given.

Birch Family.

(*Betulaceæ*)

This family is represented by three Birches and one er. One of the Birches (*Betula glandulosa* Michx.) is a small shrub occurring in swales in the mountains, eed not be mentioned further in this bulletin. None e members of this family become very large in Wyo- ;, but they are to be recognized as true trees. No thy description is necessary, for there are no trees in state with which they can be confused. As in the ow Family, the flowers are borne in separate clusters, in this on the same plant, while in the Willows they on separate plants. The male flowers are in slender, ping clusters, while the female form shorter, thicker erect aments. The numerous fruits in the cluster, ripe, are small, flattened, one-seeded nutlets with a l, thin wing at either side.

7. BIRCH.

(*Betula*)

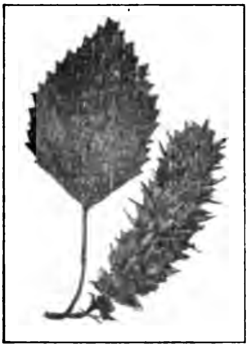
Our Birches are slender trees with slender, limber ches and rather small leaves; the seed-like nutlets dis- ly winged. The two species are easily separated by ark alone.

(1) PAPER BIRCH.

(*Betula papyrifera* Marsh)

escription.—Bark white, smooth, on young branches often with nu- dots, peeling readily into thin, paper-like layers, hence the name: ovate, small, toothed on the margins.

This species in northern and eastern America becomes quite a large tree. Since its bark was the source of the Indian's canoe it is sometimes called the "canoe birch." Since it has also often furnished the material upon which letters were written, it has always been of much interest. It is very rare in Wyoming, probably occurring only in the northeastern part, in the Black Hills. Here fine specimens of it are not rare, though they seldom attain any great size.



XXII. Paper Birch. *Leaf and fruit cluster (ament).*

(2) WESTERN BIRCH.

(*Betula occidentalis* Hook.)

Description.—Bark smooth, dark or bronze-colored: branches resin dotted: leaves ovate or sometimes nearly round, sharply toothed, rather small and thin: the very small, seed-like nut with broad wings.

This birch occurs on many of our mountain streams, usually as a mere fringe on the banks but occasionally as small thickets. It attains a height of 25 to 40 feet and furnishes slender poles often used for fencing as well as for fuel. It need never be confused with the preceding, but is less readily distinguished from the following.

8. ALDER.

(*Alnus*)

This genus is represented by one species only, and since it is of small economic value it may be treated briefly.

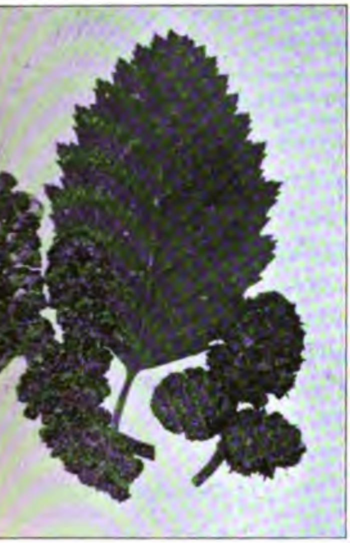
(1) PAPERLEAF ALDER.

(*Alnus tenuifolia* Nutt.)

Description.—Leaves rather large, sharply double-toothed: flowers in clustered aments, developing during the summer preceding the season in

they open and hanging naked upon the branches during the winter, ng in the spring before the leaves develop: seed-like nutlet slightly mar- but scarcely winged.

This is little more than a large shrub, but since it oc- so extensively throughout the state and lends itself so readily to transplanting it seems well to include it. It usually forms clumps of several or numerous stems from the root and grows as an overhanging fringe on the banks of mountain streamlets. Its habit of growth and the presence in winter of the naked flower clusters will help to separate it from the Western Birch, the only species with which it can be confused. It has some fuel value and often constitutes natural wind- ks that are of service to ranch homes and to stock on range. It can be used effectively for ornamenting the e grounds.



II. Paperleaf Alder. *Leaf, male flower cluster (left) and fruiting cluster.*

Beech Family.

(*Fagaceæ*)

Because of similar botanical characteristics the Oak us (*Quercus*) is placed in the above family. Since for present purposes we are concerned with a single species of Oak, we need not consume space in describing this family. but may pass at once to the genus.

9. OAK.

(*Quercus*)

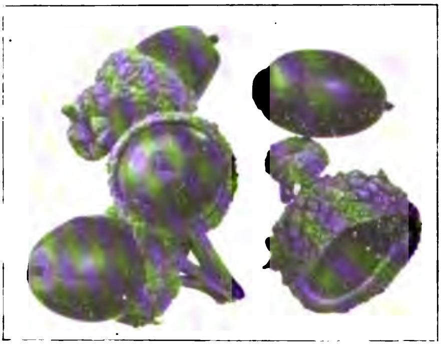
> "The monarch oak, the patriarch of the trees,
> Shoots rising up, and spreads by slow degrees:
> Three centuries he grows, and three he stays
> Supreme in state, and in three more decays."—*Dryden.*

The Oaks belong to that group of trees that are often spoken of as "hardwoods." While the quality of the wood in the several species differs greatly, yet all furnish timber of much value. As sources of lumber for furniture, implements, machinery and for all sorts of timbers where great strength is required this group holds an important place.

(1) BUR OAK.

(*Quercus macrocarpa* Michx.)

Description.—Leaves obovate, deeply lobed, the lobes rounded, pale and slightly downy beneath: nut at first wholly enclosed in the cup, becoming rather large and at maturity usually less than half enclosed: the scales of the cup conspicuous.



XXIV. Bur Oak. *Acorns and cups.*

This species has a wide range in North America and in favorable situations becomes a very large tree. Like most oaks, it thrives only at low altitudes. On that account it is something of a surprise to find it in Wyoming at all. It however, quite abundant among the hills in the lowest tions of Crook County. In such situations it is usually ch reduced in size, but here in some places it is not y well represented but many specimens become fine es 2 to 3 feet in diameter. It is one of the valuable ber trees of that county.

Maple Family.

(*Aceraceæ*)

The Maple Family has three representatives, all of m small, the Box Elder being the largest of the three. e Silver, or Soft, Maple, so largely used as a shade in the states lying to the east of this, does not occur e and will not endure the climate of many parts of this e. The species that do occur are all much hardier, are shrubby in habit and less well adapted for splanting.

10. MAPLE.

(*Acer*)

This is the only genus in this family in North Amer- All its members are trees or shrubs with watery or etish sap, the seed-like fruit in pairs and conspicuously ged. Our species are as follows:

(1) DWARF MAPLE.

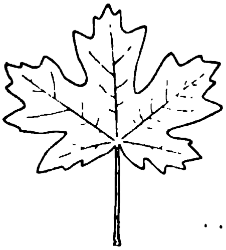
(*Acer glabrum* Torr.)

Description.—Leaves 1 to 2 inches long, smooth or nearly so on both sides, lobed, the lobes acute and sharply toothed: the winged seeds about 1 inch long.

This species is common in the foothills and the more broken areas of the state. It prefers canons and canon sides where it is hardly more than a shrub, growing in clumps of larger or smaller size. More rarely it becomes a small tree 20 to 30 feet high. It may always be recognized by its paired (opposite) buds, sharply lobed leaves, light colored bark and the paired wing-fruits. A clump or two of it on the home grounds would add much to the interest of the surroundings.

(2) LARGE-TOOTH MAPLE.

(*Acer grandidentatum* Nutt.)

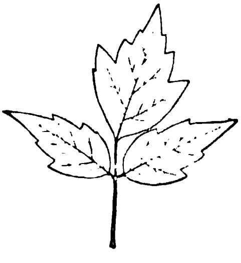


Description.—Leaves 3-lobed, the notches rounded and the lobes wavy-toothed, larger than in the preceding: seeds as in the foregoing but slightly smaller and with narrower wing.

This Maple belongs west of our range but it occurs sparsely in the southwestern part of the state and possibly along our whole western border. It is nearly related to the Sugar Maple but being small and scattering its sap is not utilized. In rare instances the trees become 35 to 40 feet high and a foot in diameter. The sketch of the leaf shows the characters that easily separate this leaf from that of the preceding. With leaf and seeds (even young ones) in hand there can be no mistaking this for any of our other trees.

(3) BOX ELDER.

(*Acer negundo* Linn.)



Description.—Leaves compound, i. e. 3 to 5 leaflets (as shown in figure) on each leafstalk, pubescent when young, smooth when old, few toothed or rarely somewhat lobed: wing-fruits paired and very similar to the preceding Maples but broader and finely veined.

We do not always think of the Box Elder as a Maple but its fruit and floral characters show that it is very osely related to the others. It is fairly plentiful throught the entire eastern part of the state along the streams. s habit is always tree-like but it rarely attains a great :e—25 to 40 feet in height and a foot in diameter being obably the maximum. It is hardy and may be readily ansplanted though in higher portions of the state it akes slow growth and may need some protection. Its uits, its leaves and the slender, drooping clusters of eenish flowers make it easily recognizable.

Olive Family.

(*Oleaceæ.*)

This family contains about a score of genera only a v of which belong to North America. Of these the mmon Lilac (*Syringa*) and the Ash (*Fraxinus*) are the st known. Since the members of this family differ eatly among themselves, our species only need be conlered.

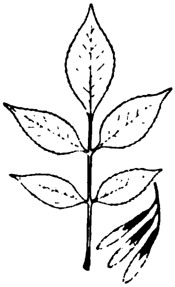
11. ASH.

(*Fraxinus.*)

Of the dozen or more species in the United States, e (possibly two) occurs in Wyoming. All are trees l some of them attain a great size, furnishing timber of ch value. They are easily known by the compound ves and the winged fruits as shown in the figure below. e fruits are borne in clusters and do not differ matery except in the relative size of the wing and the body the seed.

(1) GREEN ASH.*

(*Fraxinus lanceolatus* Borkh.)



Description.—Leaflets 5–9, finely toothed on the margins, long pointed, green on both sides: male and female flowers on different trees, in a close cluster, appearing with or before the leaves: fruits about 1¼ inches long.

This species appears but sparingly in this state, only so far as known on some of the streams in the eastern part, though probably it occurs northward in the lowest portions of the state as well. Its wood is valuable but the trees with us are too small and scattering to have any economic importance except as it may be used as a shade or ornamental tree.

Plum Family.

(*Drupaceæ.*)

This family is represented by the common Wild Plum and one species of Choke Cherry. As is well known these trees are all small, all have a fleshy fruit with a single stone-like seed.

PLUM AND CHERRY.

(*Prunus.*)

Here belong Plums and Cherries of all kinds, too well known to need any description. Our species are as follows:

---

*There is a possibility that in the Black Hills of Crook County some specimens of the Red Ash (*Fraxinus Pennsylvanica* Marsh) may be found. Though it rather closely resembles the Green Ash yet it may be known by the leaves being pale and soft, or velvety, hairy below and the body of the seed being about as long as the wing.

(1) WILD PLUM.

(*Prunus Americana* Marsh)

Description.—Leaves ovate, pointed, sharply toothed, smooth when old: ruit globose, red or yellowish; seed flattened.

This small tree occurs with more or less frequency in he northeastern counties and yields occasionally a coniderable amount of its pleasantly acid fruit. It is well vorthy of cultivation for not only does it yield better ruit and more of it, when the tree is cared for, but it is at he same time a desirable addition to the trees of the ome grounds, because of its wealth of white flowers.

(2) WESTERN CHOKE CHERRY.

(*Prunus demissa* (Nutt) Walp.)

Description.—Leaves ovate, acute, finely serrate: the white flowers in ense, cylindrical clusters: fruit when ripe nearly black.

In most localities this is only a small shrub but in ery favorable situations it becomes a tree 20 or more feet igh. The handsome, clustered flowers and fruit ought to ive it more extended use in ornamenting the home rounds. From the fruit may be made a superior jelly, specially when mixed with other native fruits such as the arberry or Buffalo Berry.

Apple Family.

(*Pomaceæ*)

Of the several genera in this family we need to notice ut two. These in common with the others have a fleshy uit formed by the thickened calyx tube which encloses e seed vessels.

13. HAW.

(Cratægus)

> "Gives not the hawthorn bush a sweeter shade
> To shepherds, looking on their silly sheep,
> Than doth a rich embroidered canopy
> To kings, that fear their subjects treachery."—*Henry VI.*

The Haw, or Hawthorn as it is often called, includes several species of small trees, mostly with short, well formed trunks, a rounded bushy top and more or less thorny or spiny branches. The small, edible, apple-like fruit with its large, bony seeds well distinguishes this genus.

(1) BLACK HAW.

(*Cratægus Douglasii rivularis* Sargent)

XXV. Black Haw.

Description.—Leaves narrowly to broadly ovate, irregularly sharply toothed, mostly green and smooth above, paler beneath: fruit black when ripe, about ⅜ of an inch in diameter: thorns stout, an inch (more or less) in length.

A small tree of fine appearance, well worthy of cultivation. Its wealth of flowers in May or June, according to altitude, and its abundant clusters of fruit which remain on the tree for a long time make it an object of much interest. There are two forms of this in the state which differ slightly in leaf form but prbably in no essential character. It occurs on most of the larger streams of the state, and may be at once separated from the next by its black fruit.

(2) LONGSPINE HAW.

(*Crataegus macracantha* (Lindl.) Loud.)

Description.—Leaves sharply double-toothed, dark green, smooth above, slightly hairy on the veins beneath: calyx glandular: fruit globose, about ⅜ of an inch in diameter, red when ripe.

This species is more shrub-like and with more straggling branches but it is equally desirable for home planting. Its wealth of white blossoms and its red fruit make it an attractive shrub or tree. While the fruit has no great value yet of the two this is probably superior to that of the preceding. This species is not known to the writer as occurring in this state outside of Crook county but it probably exists elsewhere also.

14. SERVICEBERRY.

(*Amelanchier*)

" The shad-bush, white with flowers,
Brightened the glens."—*Bryant.*

This is the name given to a few species of shrubs and small trees belonging mostly to North America, and variously known as Juneberry, 'sarvice' berry, and shad-bush. It generally occurs in broken, hilly country and produces an abundance of edible, berry-like fruits. The species given below is common throughout the Rockies and is the only one that becomes a tree in this state, and that rarely, though it is abundant as a shrub.

(1) WESTERN SERVICEBERRY.

(*Amelanchier alnifolia* Nutt.)

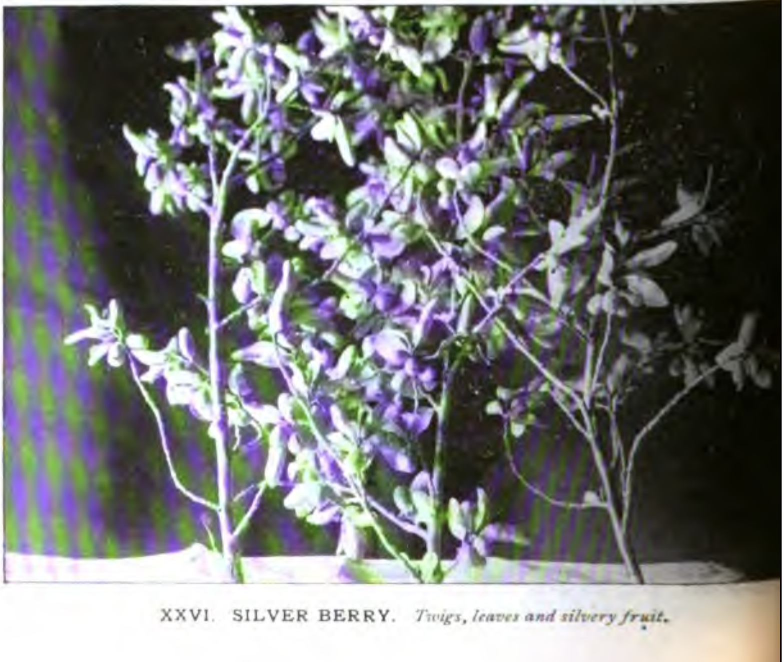
Description.—Leaves thick, rounded or elliptic, toothed around the upper half only: flowers in clusters (racemes), white, appearing before or with the leaves: fruit purple or nearly black when mature, ¼ to ⅓ inches in diameter.

Occurring among the hills throughout the state, especially along the streams at middle altitudes. The fruit is palatable, particularly if fresh, though it is used to a considerable extent as sauce and in pies. Ripening in July or August, according to altitude.

Oleaster Family.

(*Elæagnaceæ*).

Two tree-like shrubs are to be mentioned under this family because of their ornamental value. Both have silvery foliage, due to minute scales which cover the surface. both have one-seeded fruits.



XXVI. SILVER BERRY. *Twigs, leaves and silvery fruit.*

15. SILVER BERRY.

(*Elæagnus argentea* Pursh.)

Description.—Leaves elliptic, silvery-scurfy as are also the twigs, flow-
nd fruit: fruit oval, ½ inch in diameter, dry, mealy: seed large, stone-
branches without spines.

This beautiful shrub occurs in the northern and west-
parts of the state, mostly on the bluffs and ridges ad-
nt to streams. It is not common but may have a
er distribution than has yet been shown. Its perfectly
ched leaves and fruit, as to color, makes it of much
rest.

16. BUFFALO BERRY.

(*Lepargyrea argentea* (Nutt.) Greene)

—Buffalo Berry. *Twigs in fruit.*

Description.—Leaves oblong, obtuse, silvery on both sides: fruit a small, oval berry, bright scarlet when ripe, highly acid, edible: branches spiny.

This well known shrub occurs in many parts of the state, on the stream banks. Its silvery leaves and its profusion of small, scarlet berries give it a conspicuous beauty all its own. The fruits are largely gathered for the excellent jams and jellies that can be made from them. Screens and hedges of this useful shrub can be used to advantage by the landscape gardener on either home or public grounds.

XXVII. BUFFALO BERRY. *A natural hedge of well grown shrubs.*

Is it too much to hope that this bulletin may be one of the factors (however small) which shall arouse in our people a keener appreciation of the value of our forests, a more loyal support of all measures looking to their preservation, a greater interest in the beautifying of our homes and public grounds with trees and shrubbery and a more cheerful willingness to work and plant, that those who come after us may have a more wholesome and happier place in which to live? As we interest ourselves in these directions, the love of nature will grow upon us and we too shall say,

"And this our life, exempt from public haunt,
Finds tongues in trees, books in running brooks,
Sermons in stones, and good in every thing."—*Shakespeare.*

UNIVERSITY OF WYOMING.

Agricultural College Department.

YOMING EXPERIMENT STATION,

LARAMIE, WYOMING.

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JULY, 1898.

ex to Bulletins Twenty-Seven to Thirty-Seven,

JULY, 1896–JUNE, 1898.

BY THE SECRETARY.

ulletins will be sent free upon request. Address: Director Experiment
n, Laramie, Wyo.

Wyoming Agricultural Experiment Station.

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" No. 13—July, 1893. The Feeding and Management of Cattle. W. A. Henry, Ph. D., University of Wisconsin. (Reprint by Permission).

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No. 25—November, 1895. Results of Three Years' Experiments in Cost and Profit of Growing Wheat. B. C. Buffum, Agriculturist.

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etin No. 27—March, 1896. Meteorology for 1895, and Notes on Climate from 1891 to 1896. J. D. Conley, Meteorologist.

No. 28—May, 1896. First Report on the Flora of Wyoming. Aven Nelson, Botanist.

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H ANNUAL REPORT, 1896.

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TENTH ANNUAL REPORT

. . . OF THE . . .

AGRICULTURAL COLLEGE

. . . OF THE . . .

UNIVERSITY OF WYOMING

. . . AND OF THE . . .

WYOMING
GRICULTURAL EXPERIMENT STATION

FOR THE FISCAL YEAR ENDING JUNE 30, 1900.

LARAMIE, WYOMING:
CHAPLIN, SPAFFORD & MATHISON, PRINTERS.
1900.

University of Wyoming.

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o His Excellency,
Hon. De Forest Richards,
Governor of Wyoming,
Cheyenne, Wyoming.

As President and Director I have the honor to present the
enth Annual Report of the Agricultural College and the Agri-
ltural Experiment Station of Wyoming. This report covers
e work of the College and Station from July 1, 1899, to July
1900.

Copies will be sent to all Agricultural Colleges, to the
cretary of the Treasury, to the Secretary of the Interior, and
the Secretary of Agriculture, in accordance with Sections 3
Acts of Congress of August 30, 1890, and March 2, 1887.

Respectfully submitted.

Elmer E. Smiley

iversity of Wyoming,
June 30, 1900.

Faculty of the College of Agricultu

ELMER E. SMILEY, D. D., President,
Professor of Political Science.

*BURT C. BUFFUM, M. S.,
Professor of Agriculture and Horticulture.

AVEN NELSON, M. S., M. A.,
Professor of Biology.

HENRY MERZ, M. A.,
Professor of German and Social Science.

EDWIN E. SLOSSON, M. S.,
Professor of Chemistry.

WILBUR C. KNIGHT, M. A., F. G. S. A.,
Professor of Geology.

IRENE M. MORSE, M. A.,
Professor of French and History.

CHARLES B. RIDGAWAY, M. A.,
Professor of Mathematics and Physics.

LOUISE H. MOREY, B. A.,
Professor of English.

WILLIAM F. GILKISON, B. S., M. E.,
Professor of Drawing and Industrials.

Professor of Military Science and Tactics.

FRANK H. H. ROBERTS, B. Ped., M. A.,
Assistant in Mathematics.

CHARLES H. FULTON, M. E.,
Assistant in Geology.

JUNE E. DOWNEY, M. A.,
Assistant in English and Philosophy.

DANIEL C. ROYER, Q. T.,
Instructor in Bookkeeping.

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*Resigned to accept chair of agriculture at Colorado A
College, Fort Collins, Colorado. Prof. Luther Foster, M. S. A.
Utah, elected to fill vacancy.

TENTH ANNUAL REPORT

. . . OF THE . . .

Agricultural College of the University of Wyoming.

I hereby submit the tenth annual report of the College f Agriculture of Wyoming, in compliance with enactment of ongress. Following this report is a paper written by our hemist, Professor Edwin E. Slosson, and Mr. R. B. Moudy, of st year's senior class, on The Cement Plaster of Laramie. his will be found an interesting monograph on a growing ome industry.

INCEPTION OF THE COLLEGE.

The first president of the university of Wyoming, when nstructing the various courses of the institution, in accord- ce with the act of incorporation, planned for distinct schools agriculture and mechanic arts. These departments did not tain much growth until 1891.

On the 10th of January of that year they were organized o separate colleges by an act of the legislature of Wyoming, ich vested the control of the appropriations from the Morrill t of Congress in the Board of Trustees of the State univer- y. The Morrill Act, approved August 30, 1890, was intend- to grant an endowment for agricultural and mechanical leges in addition to that obtained by a land grant on July 2, 62.

PRESENT MANAGEMENT AND COURSE.

The Board of Trustees, whose names appear on a pre- ing page, has not changed since the last report.

The Faculty of the College, with the position held member, appears on another page. During the past only change in the Faculty was occasioned by the resign Professor B. C. Buffum, M. S., who has held the chair culture and horticulture in our institution for the p years. He has been honored with a call to her chair of ture by his *alma mater,* the Colorado Agricultural Colle Collins, Colorado.

Whenever a consolidation of classes has been poss professor of a subject has been employed in the College eral Arts. Thus considerable expense has been save state and an economical management effected.

The various courses in agriculture and mechan gineering have been appended to this part of the rep will be found to present as high a standard as those of ilar institution in the country. The model offered by t mittee on Courses of the American Association of Agr Colleges and Experiment Stations has been closely fol

EQUIPMENT.

The laboratory facilities of the Agricultural Col the same as those of the University and are very good branches of science; the comparatively small numbe dents in the higher classes gives opportunities for per tention from instructors and the use of better appara in most large institutions.

THE PHYSICAL LABORATORY is fitted with water. electricity, and accommodates students in sections of four at once. The method of conducting the laborato in elementary classes is that which is sometimes know "collective system." Under this method all are engage same experiment at the same time, thus allowing the t instruct the whole class at once on difficult points, leaving him free to devote the greater portion of his assisting those who need particular attention. Each elementary student performs a series of experiments in accurate measurements and weights; friction machines, and composition of forces; properties of matter; the pendulum; heat; magnetism; electricity, testing of resistance and making of cells, etc. Advanced students have the use of accurate instruments for electrical measurements, motor, dynamo, and statical electrical machines, X-ray apparatus, phonograph, telephones, electrical heater, siren, etc. The field work in surveying included in this department covers the use of the Wye-level, compass, transit, nd solar attachment.

THE GEOLOGICAL LABORATORY contains facilities for study-
ng mineralogy, geology, and paleontology. Students of min-
ralogy determine in the first term some fifty minerals with the
low-pipe and familiarize themselves with two hundred more.
or advanced students in mineralogy there are two petrograph-
al microscopes, with rock sections and instruments for pre-
aring the sections. The collection of rock specimens for class
e now numbers six hundred. The opportunities for field
ork in geology are fully described in the department state-
ent. The paleontological collection is being rapidly enlarged
om Wyoming fields and already affords ample material for
iginal work.

THE CHEMICAL LABORATORY has locked desks, provided
th gas and water, for thirty-six students. Elementary stu-
nts perform about one hundred experiments, many of them
antitative, and then make complete qualitative analysis of
enty mixtures. Advanced students have all necessary appa-
us for difficult organic and inorganic preparations, quantita-
e analysis, including organic, gas, sugar, and electrolytic
lysis, and determination of heat of combusion with the bomb
orimeter.

THE BIOLOGICAL LABORATORY is provided with si water, excellent compound and dissecting microscopes tomes, turntables, waterbaths, charts, models, photogra paratus, and the necessary appliances for bacteriologic

THE MACHINE SHOPS are run as nearly as possibl respond with actual manufacturing establishments. wood room each student has his own chest of tools fo work and has the use of turning lathes, pattern make mer, mortising machine, pony planer, short jointer, bo chine, band saw, scroll saw, variety wood worker, and saw with two cross cut and two rip saws. The iron provided with a 24 inch x 24 inch x 6 foot planer, a 25 i geared power feed drill press, a universal milling ma 14 inch x 6 foot engine lathe, a 16 inch x 6 foot engine power back saw, a twist drill grinder, a power pipe-t machine, a 14 inch sensitive drill, and an emery grin two 14 inch wheels. The foundry contains a Whiting 32 inch outside diameter lined down to a 23 inch, whi capacity of melting from 1,000 to 2,000 pounds of iron It is also provided with six 50 pound ladles, one 20 ladle, core oven, flasks, riddles, bellows, and all tools n to operate a first-class foundry. There are also comp of piping tools for steam fitting, and a forge for sharpe tempering. Advanced classes have the use of an Thompson Indicator and Arndt's Econometer with take indicator cards and test the efficiency of boilers.

MUSEUM.

A good start has been made on an Agricultural but until we have more room little further can be do direction. The cases are large and built of substa They contain a collection of specimens of the cultiva and wild grasses of Wyoming. With the collection of the seeds of each in neat exhibit bottles. The exhibi cludes some rare seeds from Africa, Japan, and other foreign countries. The cereals and forage crops raised on the Laramie experiment farm occupy one case. They are arranged in an artistic manner and contain heads of grain that for size and perfection of shape are rarely surpassed. The exhibition of wild grasses consists of a portion of those sent to the World's Fair in 1893, which received the award of a medal and diploma. The fruits of our state are not as yet represented, but some work has been done in reproducing the fruit in wax, thus making it possible to keep them on exhibition in permanent form.

The collection contained in this museum is instructive to the student and gives the stranger a good idea of what Wyoming is capable of in agriculture.

ROCKY MOUNTAIN HERBARIUM.

We have by all odds the largest and most representative ollection of Rocky mountain plants to be found anywhere. On his account we have seen fit to give the name of Rocky Mounain Herbarium to our collection.

The Herbarium now contains about 22,000 specimens. It s a fair working collection of the plants of the Western United States, being rich in those of the Rocky Mountains, and esecially of Wyoming. A steady growth is maintained, collecions of much value being added each year. It represents the ora of Wyoming so far as known and is becoming of more nd more interest to students who desire to make a special tudy of the plants of this range, especially so since it contains e types of many new species recently described. The Herarium is open to University students and others whose previus training is such as to enable them to profit by its use.

NEW BUILDING.

A new building, which will be known as the Hall of Scince, is now in course of erection. Only the central or main art will be erected at present; for the building has been so planned that wings may be added, as more room shall b ed. The portion of the building now being constructed 50 x 80 feet, with a two-story extension on the rear, a cost $35,000.

The whole lower floor will be occupied by the muse with the ceiling sixteen feet high there will be room for g around the sides. The second floor of the building wil voted to biology, and will include a large scientific lab and class room. On the east side of the building, openi the second floor, there will be a large lecture room for of the professors who occupy the building. This will be in amphitheater style, so that every seat will have a go of the demonstration tables and the experiments per there. This lecture room will seat over 100 persons a be very convenient for evening entertainments. The thi will be occupied by the chemical department, and will laboratories for students in elementary and analytical ch and for research work in the experiment station. Th will be well lighted and ventilated, and there will be supply furnished by a tank in the top of the building. T and floors will be fire-proof.

The general style of the building is the collegiate the material used is the same gray sandstone as in th buildings, and is to be found in abundance in the hi town.

Departmental Statements.

The following is a detailed report of each department of
ne College of Agriculture:

POLITICAL SCIENCE.

This department includes civics, public law, political econ-
my, and sociology. Its aim has been to cultivate independent
hought and foster intelligent citizenship. After the origin
nd growth of each subject has been investigated, and the gene-
al principles have been acquired, the student is required to ap-
ly the principles thus obtained to leading problems of the pres-
nt day. Debates, public and private, form an important fea-
ure of the courses. The following subjects are offered:

II. *Constitutional Law.* Cooley; Black. Examination
f cases; lectures debates. [Elective for agricultural seniors.]

III. *International Law.* Walker; Gallaudet; Woolsey;
now's Cases. Lectures; debates; theses. [Elective for agri-
ultural seniors.]

IV. *Political Economy.* Ely's Introduction; Walker;
arshal; Gregory. Lectures; debates; theses. [Required
agricultural and mechanical seniors.]

VII. *Comparative Government.* Wilson's The State;
enzel's Comparative View of Government; Bagehot's Eng-
h Constitution; Helie's Les Constitutions de France; Nicol-
n's Sketch of the German Constitution; Bryce's American
ommonwealth. Lectures; theses. [Elective for seniors.]

SOCIAL SCIENCE.

The aim of this department is to familiarize students with
e history of social development and to encourage investiga-
n of the principles on which social progress depends. After

a thorough grounding in the fundamental facts, the stu expected to observe the social phenomena about him study the various problems in an independent manner. much as sociology is a science of recent birth, and its t are constantly expanding, much of the class-work con lectures and theses. The following subjects are offered

I. *Principles of Sociology.* Small and Vincent dings; Kidd's Social Evolution. Lectures; theses; d [Elective for agricultural seniors.]

II. *Social Problems.* Study of crime, suicide, in pauperism, charities, intemperance, socialism, educatio Discussions; theses. [Elective for agricultural senio have taken I and Philosophy IV.]

III. *Social Philosophy.* Lectures on social theori and new, and on the aims of society. Discussions: [Elective for agricultural seniors who have taken I and

PHILOSOPHY.

The work of this department is intended to furnish quaintance with philosophic thought, to afford a trai the methods of investigating philosophic phenomena, imbue the student with the latest methods of education cial attention is given to physiological psychology. Th in this subject is illustrated by charts and models of th and sense organs and by the introduction of various ments. In teaching logic more time than formerly is g inductive reasoning, as a perfect knowledge of this especially helpful to scientific students and to those in to do research work in philosophy.

I. *Psychology, Introductory.* James's Briefer P ogy, or Titchener's Outlines of Psychology. Collater ings. The purpose of this course is to give the student into the principal psychological conceptions and metho practice in simple psychological experimentation. [Required of agricultural juniors.]

II. *Psychology, Advanced.* Investigation of special topics. Reading, observation, experiment. [Elective for those students who have taken I; winter term; five times a week.]

III. *Logic.* Jevons-Hill's Elements of Logic as text, with Fowler, Bain, Sidgwick, and others for reference. Treatment of the proposition, immediate and mediate inference, the hypothesis, arguments, and fallacies. Special attention to the principles and methods of induction. [Elective for agricultural seniors.]

IV. *Ethics.* Markenzie's Manual of Ethics, or Muirhead's Elements of Ethics. Lectures and discussions, with eadings from Plato, Aristotle, Kant, Mill, Spencer, and oth- rs. A critical examination of different ethical theories, chiefly, Hedonism, ancient and modern; Rigorism; and Evolutionary Utilitarianism. [Elective for juniors and seniors; spring erm; five times a week.]

BIOLOGY.

The department of biology as at present organized includes otany, zoology and physiology.

Even in the introductory courses laboratory work is made prominent feature in order that from the first students may ecome self-reliant.

The equipment of the department has been adequate to the emands made upon it, and as new necessities arise in connec- on with the several courses, they will be supplied as far as pos- ble from the resources at command.

One of the two rooms of the department is a convenient cture room having, among its other equipments, a lantern with icroscope attachment. This enables the instructor to illustrate the screen by both lantern and microscope slides the subject nder discussion.

The laboratory is large and well lighted, and is f with working tables, desks, and all necessary apparat following subjects are offered:

BOTANY.

I, II, III. *General.* The purpose of this intr course is to give a general view of the entire field. T progresses from the simplest plants to the more sp forms. The first and second terms are devoted to t phology and physiology of plants, and the third term to ogy and classification of phanerogams. [Required of tural freshmen.]

IV, V. *Histology and Physiology.* A course in h and experimental physiology of the higher plants, with a consideration of some of the special problems reproduction and morphology. [Elective for agricul niors.]

VI. *Mycology.* Fungi in general, but with sp tention paid to those of economic importance. [Ele agricultural seniors.]

ZOOLOGY.

I, II, III. *General.* The aim is to acquaint the with the main facts of animal structure, physiology an fication, by means of lectures, laboratory work on typ mal forms, and prescribed reading. It is a prerequisit other courses in Zoology. [Required of agricultura mores.]

IV, V. *Comparative Anatomy of Vertebrates.* of the principal problems connected with the successiv cation of the different organs in the several classes of [Elective for those who have taken I, II, and III.]

VI. *Microscopical Anatomy.* Microscopical te methods of investigation, and the preparation of s normal vertebrate tssues. [Elective for agricultural

PHYSIOLOGY.

A brief course in Physiology, with special reference to the unctions and hygiene of the more important organs of the hu- nan body. Only so much of anatomy will be given as seems iecessary for the comprehension of these two phases of the ubject. To the student and citizen those questions which per- ain to the health of the individual and the community are of rime importance. These as related to home and municipal anitation will have special attention. Lectures, recitations, nd laboratory work. [Required of agricultural juniors; win- er term.]

AGRICULTURE.

The instruction in agriculture aims to give the student ne greatest possible knowledge of the science of agricultural ractice in the time given. The larger part of the instruction is y lectures. Where text-books are used, they are supplemented v lectures, keeping the student abreast of the times.

Up to the senior year, as often as the other work will per- it, students are required to work in the green-house or upon e agricultural grounds or experiment farm two hours each ternoon. As far as possible, the work is made to illustrate e branch being taught. The agricultural museum furnishes aterial with which to illustrate the study of farm crops and the ricultural productions of the world.

In the work upon the farm and the instruction in the class- om, the methods and results of the experiment station are ways before the student. These will afford him much general ormation regarding the practice of agriculture in this region, d will give him an insight into the way by which important ts are deduced from the mass of daily observations and es. The following subjects are required:

I. *History of Agriculture.* Taught by lectures and refer- e books, such as Goss's Principles of Plant Culture, and

Johnson's How Plants Grow, and How Plants Feed. outline of the history of agriculture, followed by a course in the principles of plant culitvation and grow quired of agricultural sophomores.]

II. *Soils, Tillage, and Fertilizers.* Taught by lec reference books, such as King's The Soil, and Storer's ture. [Required of agricultural sophomores.]

III. *Farm Crops.* Lectures. Planting, irrigat vesting, and marketing; laying out and improvin farm management and farm accounts. The students will include setting up and running farm machinery, and irrigating crops properly. [Required of agricultu omores.]

IV, V. *Breeds of Live Stock.* Curtiss's Breeds Stock, Warfield's Cattle Breeding, and Miles' Stock supplemented by lectures and practice in judging by points. [Required of agricultural juniors.]

VI. *Stock Feeding and Dairy Management.* Cattle Feeding, Henry's Cattle Feeding, and lecture quired of agricultural juniors.]

HORTICULTURE.

The instruction in this department aims to give dent a good general foundation in the science of g plant cultivvation, fruit raising, landscape and orname dening. During the spring term of one year, two hour ratory work each week in the multiplication of plants, budding, and making cuttings, are required. The subjects are offered:

I. *Plant Forcing.* Study of green-houses and and of the cultivation and propagation of vegetables fruits. Lectures. [Required of agricultural juniors.

II. *Pomology.* Pruning, grafting, budding, cutt orcharding. Lectures. [Required of agricultural ju

III. *Landscape and Ornamental Gardening.* Lectures. Elective for agricultural seniors.]

IV. *Thesis Work.* Pollination, cross fertilization, variaon, or other advanced subject. [Elective for agricultural seiors.]

ENTOMOLOGY.

This department aims to give the student an insight into isect life, and to afford some knowledge of economic entoiology through the study of injurious insects and the means r their extermination. The following subjects are required:

I. *Elementary.* Packard's Entomology, with Comstock r reference. Lectures. [Required of agricultural juniors.]

II. *Economic Entomology.* Smith's Economic Entomoly, supplemented by lectures. [Required of agricultural juors.]

IRRRIGATION.

The object of this department is to give a general idea of principles of irrigation practice and water measurement.

I. *Principles.* Effects of water on soil and crops, and asurement of water. Wilson's Irrigation Engineering. Leces, reference reading, and practical work. [Required of agultural juniors.]

CHEMISTRY.

The work of all courses in the department of chemistry xperimental and inductive so far as consistent with the acrement of the necessary amount of general information. Stuts are from the first encouraged to work independently on s of investigation in which they are specially interested.

The department of chemistry occupies four rooms in the th end of the Hall of Language. One room contains the lytical balances and the chemical reference library, the sec is devoted to the experimental work of the Wyoming Agricultural Experiment Station, the third is a lecture room fourth and largest room is fitted up for the classes in q and quantitative analysis. The department is well equi research and analytical work in organic and inorganic try. The following subjects are offered:

I, II. *Elementary.* Storer and Lindsay. The ai course is to give students a knowledge of the laws of change, a practical familiarity with the principal elem compounds, and skill in manipulation of apparatus. [of agricultural and mechanical sophomores.]

III. *Qualitative Analysis.* Caldwell's Qualitativ sis. Students acquire the ability to detect the ordin and bases in any substance. [Required of agricultural chanical sophomores.]

IV. *Quantitative Analysis.* Caldwell and F Twenty simple gravimetric and volumetric deter [Elective for students who have taken III.]

VI. *Inorganic Preparations.* Erdmann's Anlei Darstellung chemischer Präparate. Preparation of a of difficult compounds and elements. [Open to stud have taken III; spring term; laboratory work ten week.]

VII. *Organic Chemistry.* Remsen's Organic C Lectures and recitations on the compounds of carbo quired of agricultural juniors; fall term; five times a

VIII. *Organic Preparations.* Gatterman; Methods in Organic Chemistry. [Open to students taken VII; winter term; laboratory work ten hours

XI. *Agricultural Chemistry.* The chemistry growth, and the application of chemical principles to agriculture, with special reference to the problems of region. [Required of agricultural juniors: winter te tures three hours and laboratory work four hours a w

XII. *Applied Chemistry.* Lectures on chemical processes and manufactures not included in metallurgy, and on methods of analysis and control. Most attention is paid to subjects of practical importance in Wyoming; such as petroleum and its products; coal, gas, and coke; building stone and cements; alkalies and acids; beet sugar; glass; air and water supply. [Required of mechanical juniors.]

GEOLOGY.

Most of the instruction in this department is given by lectures, but text-books are used for reference, together with the latest geological reports.

The location of the Agricultural College is exceptionally advantageous for the study of geology. Only a few miles east, the Laramie mountains rise nearly 2,000 feet above the campus, while to the westward the Medicine Bow mountains rise 5,000 feet. Both of these mountain ranges are mineralized, and mining has been carried on for many years. They furnish rich ields for the student of structural and dynamical geology, as well as for those who wish to study almost new Archæan exosures. Flanking these ranges are Paleozoic, Mesozoic, and Cenozoic rocks that have been exposed by the mountain making nd subsequent erosion, so that a student may easily make himelf familiar with the entire series of Rocky Mountain sedinentary rocks. The working collections of rocks and fossils n the department are not large, but are well selected and are ncreasing in size very rapidly. The collection of Mesozoic inertebrates is very complete and the collection of Jurassic verterates is the second in size in the United States. To those who ish to study economic geology special inducements can be ffered, since ores of economic value are numerous, and are nly a short distance away from the university. The plains are so well supplied with mines of coal and deposits of clay, gypm and building stones.

The following list of books is used for reference a
work in this department: Le Conte, Dana, Geikie,
Lake, Lapparent, Tarr, Zittel, and Nicholson and Ly
The following subjects are offered:

I. *Dynamical and Structural.* Geological forces
tions in which stratified rocks are found, and general t
phy. Lectures; Le Conte and Dana as texts. [Requ
agricultural juniors.]

II. *Mineralogical.* Elementary study of minera
which a student is required to determine fifty species of
minerals with the blow-pipe. Lectures; Crosby and B
texts. [Required of agricultural juniors.]

III. *Historical.* Study of fossilized life associat
stratified rocks, and methods of determining formatio
associated fossil life. Lectures; Le Conte and Dana a
[Required of agricultural juniors.]

IV. *Economic.* Study of the minerals of econo
portance and methods of preparing them for the marke
tures; Kemp and Tarr as texts. [Elective for agricult
niors.]

V. *Paleontological.* Elementary course in paleo
Lectures; Nicholson and Lydekker as text. [Elective
cultural seniors.]

VI. *Advanced.* Course arranged to suit the need
dents. One week in the field. [Elective for agricult
niors.]

HISTORY.

The purpose of the department of history is to
taste for historical reading and give the ability to com
rightly the events of the times by applying the exper
the past to the conditions and problems of today. Th
not the accumulation of a mass of facts and dates, bu
quisition of a right comprehension of great historical

Text-books are used, especially in the preparatory classes; but the study of the assigned lessons is supplemented by reading different authorities on the same subject and by lectures. The historical library has been greatly enlarged during the past year and is at the disposal of the students in this department: The following courses are offered:

I. *England.* Montgomery's English History. [Required of preparatory students.]

II, III. *Mediaeval and Modern.* Myer's Mediaeval and Modern History. [Required of preparatory students.]

IV. *Greece.* Myers' History of Greece; Guerber's Mythology. [Elective for agricultural seniors.]

V, VI, VII. *Middle Ages.* Thatcher and Schwill. Lectures and supplementary reading. [Elective for agricultural seniors.]

ENGLISH.

The aim of the preparatory work in this department is to teach the students to understand and use the English language correctly and to cultivate in them a taste for the best literature. A thorough mastery of English grammar is required before entrance to the Preparatory Year.

The student's work in literature is made to furnish the occasion as well as the material for the preparation of essays. These essays are subject to criticism both in the class and with he individual writers.

The formal study of rhetoric is designed to ground the tudent in the principles of English composition and to cultivate his literary sense by analytical study.

The work in oratory is of a practical character. An effort s made to secure reading that shall be intelligent, natural and orcible, and to develop spontaneous expression from the men-al side. The student meets the instructor personally for re-earsal and criticism.

The following subjects are open:

I, II, III. *Composition and Rhetoric.* Constant
in writing. Hill's Foundations of Rhetoric. Selectio
the following American authors are read, and pass
memorized: Irving, Bryant, Longfellow, Whittier,
Holmes. Supplementary reading. [Required of agr
and mechanical preparatory students; three terms; fi
a week.]

VII, VIII, IX. *Literary Masterpieces.* Reading,
sition, memorizing selections. The books prescribed ar
den's Palamon and Arcite: Pope's Translation of t
Books I, VI, XXII, XXIV; The Sir Roger de Coverl
in the Spectator; Goldsmith's Vicar of Wakefield;
Ivanhoe; De Quincey's Flight of a Tartar Tribe;
Last of the Mohicans; Selections from Tennyson's Idy
King: Hawthorne's House of Seven Gables. [Req
agricultural freshmen; three terms; once a week.]

X, XI, XII. *History of Literature.* History of
and American literature. Selected reading: com
recitations. [Required of agricultural sophomores
chanical juniors.]

XIII, XIV, XV. *English Poets.* Chaucer and
Burns, Wordsworth, Coleridge, Byron, Keats, Shelley;
son and Browning. Critical reading of selected poe
study of the literary art of the poets. Comparative stu
pers on topics connected with works read. Reading by
fessor with requisite comments. Special attention is
the grammar and pronunciation of Chaucer's works
quired of agricultural sophomores: three terms: thr
a week.]

XIX, XX, XXI. *Oratory.* Study of selectio
great English and American orators. Composition.
tions and declamations which are subject to criticism
professor and by the class. Every member of this cla

quired to deliver in public one original oration at the end of ach term. [Required of agricultural and mechanical seniors; hree terms; once a week.]

MATHEMATICS.

The instruction in mathematics aims to develop the powers of mental concentration, to give facility in attacking original problems, and ability to recognize the difference between ogical proof and presumptive evidence, and to form in the student the habit of expressing his ideas in concise mathematical anguage.

All fundamental concepts are presented in as many different forms as possible, with fullness of explanation and variety of illustration, so that the student may thoroughly understand ll the principles involved.

The following subjects are required:

I, II, III, IV. *Algebra.* Wentworth, Wells, Taylor, or Charles Smith. Fundamental operations. Fractions and fractional equations, simultaneous equations of the first degree. Problems involving two unknown numbers, simple and indeterminate equations, involution and evolution. Radical and imaginary expressions, quadratic equations, ratio and proportion. Required of preparatory students and freshmen.]

V, VI. *Plane Geometry.* Wells, Wentworth, Chauvenet, r Beman and Smith. Much of the time is devoted to solving riginal propositions, and when time permits, some of the modern methods and the geometrical theory of proportion are aught. [Required of freshmen.]

VII. *Advanced Algebra.* Wells' College Algebra. Progressions, binomial theorem, convergent and divergent series, ndetermined coefficients, logarithms, permutations and combinations, summation of series, determinants, theory of equations, solution of higher equations. [Required of mechanical phomores.]

IX. *Trigonometry.* Wells' New Trigonometry. velopment of the general formulae and their applicatio solution of triangles, polygons, and original field p [Required of agricultural juniors and mechanical sopho

X. *Analytical Geometry.* Wentworth's Analytica etry. The analytical geometry of the straight line, cir conic sections; including a general discussion of the equation of the second degree, and an introduction to ometry of three dimensions. [Required of mechanical elective for agricultural seniors.]

XI, XII. *Calculus.* Osborne's Calculus. Differe of functions, successive differentiation, indeterminate development of functions in series, maxima and minim tions of two or more variables, tangents, normals, asy direction of curvature, singular points, curve tracing, e envelopes, and order of contact. Integration, applic geometry and mechanics, successive integration, integr rational fractions, integration by rationalization, by p by series, lengths and areas of plane curves, areas of su revolution, and volumes of solids. [Required of me juniors; elective for agricultural seniors.]

PHYSICS.

The aims of this department are to cultivate in the habits of thoughtful observation, intelligent and rapid lation, and to give him a general knowledge of natu nomena. In all courses the subjects are studied from perimental side, the student spending at least one-hal time allotted to the work in the laboratory under the d pervision of the professor in charge.

The following subjects are offered:

I, II, III. *Elementary.* Carhart and Chute's Ele Physics; Allen's Laboratory Physics. The properties ter; mechanics of solids and liquids. Heat, sound, and light. Magnetism and electricity. [Required of freshmen.]

IV, V, VI. *General.* Barker's Physics. Outlined experiments with reference to laboratory manuals. Physical quantities, kinematics, dynamics, work and energy, attraction and potential, and properties of matter. Energy of mass vibration, molecular kinetic energy, radiant energy. Energy of aether-stress, energy of aether-vortices, energy of aether-flow, and the electromagnetic character of radiation. [Required of mechanical juniors and elective for agricultural seniors.]

VII. *Electric Measurements.* Measurements of resistances, calibration of amperemeters and voltmeters, calculation of the electromotive force of batteries and dynamos, magnetic determinations, heating effect of currents, etc. [Elective for gricultural seniors.]

MECHANICS.

The aim of the instruction in this department is to give
he student a thorough insight into the general principles gov-
rning prime movers and mechanical movements, and acquaint-
nce with the methods in which these principles may be applied
nd combined in order to produce the desired effect in all
ranches of engineering. Instruction is also given in subjects
hich are rather more technical than theoretical, and the appli-
tion of theory to practice is never lost sight of. The work is
lly illustrated by frequent reference to the engineering and
echanical equipment of the university and other available
urces.

The following subjects are required of mechanical stu-
nts:

I, II. *Founding.* Lectures on core making, loam, dry and
een sand molding; cast iron; flasks, facing, finishing, etc.;
so on preparing, charging, tapping out, and stopping up the
pola. [Required of mechanical freshmen.]

III. *Iron Working Machines.* Joshua Rose's
Practical Machinist. Study of the use and care of
chinery, particularly the lathe; speed of different part
cutting, turning eccentrics, taps and dies; fitting co
rods; pumps, etc. [Required of mechanical juniors; f
five times a week.]

IV. *Elements of Mechanism.* Stahl and Wo
mentary Mechanism. Study of the elementary princ
derlying mechanical movements and the modes of com
ing motion. [Required of mechanical juniors; wint
five times a week.]

V. *Steam Boilers.* A Treatise on Steam Boilers,
son and Flather. A general study of the different
modern steam boilers, their construction, advantages,
advantages. [Required of mechanical seniors; fall te
times a week.]

VI. *Steam Engines.* The Steam Engine, by Hol
mechanism and principles brought into use in the desi
modern steam engine. Gidding's adjustable model
versal valve movements is used in the class room.
study is also made of working engines. [Required of
cal seniors; fall term; five times a week.]

VII. *Steam Engine Indicators.* The Slide V
Rose, and Hemenway's Steam Engine Indicators.
different engines are tested as time will permit. [Re
mechanical seniors; winter term; five times a week.]

VIII. *Engineering Materials.* Merriman's Mec
Materials. Theory of resistance of different mater
study of those principally used in engineering, especia
stone, timber, iron, and steel. [Required of mechanical
winter term; five times a week.]

IX. *Hydraulics.* A Treatise on Hydraulics, b
man. The flow of water through tubes, in pipes, canal
and over weirs; measurement of water power, and pr

owing water. [Required of mechanical seniors; spring term; ve times a week.]

X. *Thermodynamics of Gases.* A study of the properties gases, saturated vapor, and superheated steam, and their apication to the steam engine. [Elective for mechanical seniors; ring term; five times a week.]

DRAWING.

The aim of the department of drawing is to develop and icken the ability of observation and to follow as closely as ossible the line of work done in the practical drafting rooms machine shops.

The following subjects are required:

I. *Freehand Drawing.* Drawing from models and copies, th which the department is well supplied. [Required of agriltural freshmen, and of mechanical preparatory students.]

II. *Freehand Drawing.* Sketching parts of machines to used in instrumental drawing. [Required of agricultural eshmen and of mechanical preparatory students.]

III. *Use of Instruments.* A short course in straight and rved lines and lettering. [Required of agricultural freshmen d of mechanical freshmen.]

IV. *Geometrical Constructions.* Geometrical problems ed in instrumental drawing. [Required of mechanical freshn.]

V. *Descriptive Geometry.* An elementary course in protion. [Required of mechanical freshmen.]

VI, VII. *Instrumental Drawing.* Detailed copies of ts of machines. Drawing to scale of parts of machines from tches taken in the shops by the students. [Required of menical sophomores.]

VIII, IX. *Shades and Engineering Colors.* Drawing and ing machines and parts of machines. [Required of mechansophomores and juniors.]

X. *Parts of Machines.* Designing gears, cams, of machines which apply to the study of Mechanics quired of mechanical juniors.]

XI. *Blue Prints.* Tracing and making draw used in the shops. [Required of mechanical juniors.

XII. *Machine Designing.* Designing a boile simple machines; the design to be as original as poss quired of mechanical seniors.]

XIII. *Steam Engine Drawing.* This subject is pany the work in Mechanics V and VI. [Required ical seniors.]

INDUSTRIALS.

This department is intended to simplify mech gineering by teaching practical work in connection theory. It aims also to present the practical side of by running the machine shops as nearly as possible o ciple of actual manufacturing establishments.

I, II. *Wood Working.* Lectures on the care an ment of carpenters' tools; exercises in lining, planin notching, splicing mortising, and tenoning. Benc wood; exercises in dovetailing, framing, paneling, work for the department. [Required of agricultur chanical preparatory students.]

III. *Wood Turning.* Exercises in straight a turning, compound curves, etc. [Required of agric mechanical preparatory students.]

IV. *Pattern Making.* A large variety of pa cluding parts of machines, are made for use in th [Required of mechanical freshmen.]

V, VI. *Foundry Practice.* Exercises in mould ing, charging, and managing the cupola. The ca tained are used by the students in the machine ro quired of mechanical freshmen.]

VII. *Iron Work.* Exercises in filing and chipping, and
e use of the drill press. [Required of mechanical sopho-
ores.]

VIII. *Iron Planing.* Exercises and special work. [Re-
ired of mechanical sophomores.]

IX. *The Engine Lathe.* An elementary course; tapering,
ew cuting, etc. [Required of mechanical sophomores.]

X. *The Engine Lathe, Advanced.* Special work; turning
parts of machines, and work for the department. [Required
mechanical juniors.]

XI. *Milling.* Exercises in milling, sawing, gear cutting,
ral cutting, and work on parts of machines. [Required of
chanical juniors.]

XII. *Engineering Laboratory.* Testing the efficiency of
lers, and inspection visits. [Required of mechanical juniors.]

XIII. *Engineering Laboratory.* Testing steam engines,
ning the principles and operation of the steam engine indi-
or and rigging; inspection visits. [Required of mechanical
iors.]

XIV. *Shop Engineering.* General work in shop manage-
t, lining shaftings, and setting machines; inspection visits
quired of mechanical seniors.]

XV. *Experimental Laboratory.* A thesis is produced in
ection with experimental work. [Required of mechanical
ors.]

Special subjects of experiment are arranged for those who
taken the baccalaureate of science in mechanics and wish
ke graduate work.

MILITARY SCIENCE AND TACTICS.

The department of Military Science and Tactics is estab-
l in accordance with the requirements of an Act of Con-
donating public lands to colleges, one of the conditions
that military tactics shall be taught. It is under the con-

trol of the officer of the regular army, detailed by the partment for its duty, without any expense to the St the provisions of Section 1225, Revised Statutes of t States. One hundred and fifty Springfield rifles (tern; similar to those used at West Point) and ec and cannon and sabres for artillery and cavalry pr loaned to the college by the U. S. Ordnance Depart allowance of ammunition is annually supplied by t government for purposes of target practice. All st required to drill throughout the year. The cadet o appointed by the commandant of cadets, subject to th of the president. The commissioned officers are usu ed from the senior class, the sergeants from the ju and the corporals from the sophomore class, general military efficiency being the qualifications considered.

Besides obtaining the excellent physical results low systematic and regular military training, the the students will be thus improved. The virtues of honor, and truthfulness are cultivated, and habits of promptness and obedience are insisted upon.

The rules prescribed by the President of the Uni for the gǒvernment of officers of the army detailed a ors of Military Science and Tactics require the followi of instruction:

1. The course of instruction shall be both pra theoretical, and shall be so arranged as to occupy at hour per week for theoretical instruction, and at least per week for practical instruction.

2. The practical course in infantry shall embr arm target practice, and, as far as possible, all the n prescribed by the drill regulations of the United St applicable to a battalion. Instruction in artillery shall as far as practicable, such portions of the United S regulations as pertain to the formation of detachment

f the piece, mechanical maneuvers, aiming drill, saber exercise, nd target practice. Instruction should also include the duty f sentinels, and where practicable, castrametation. Such in-ruction shall be given by the Professor of Military Science nd Tactics personally, or under his immediate supervision.

3. Theoretical instruction shall be by recitations and lec-ures personally conducted and given by the Professor of Mili-ary Science and Tactics, and shall include, as far as practica-le, a systematic and progressive course in the following sub-cts: The drill regulations of the United States army, the prep-ration of the usual reports and returns pertaining to a com-any, the organization and administration of the United States rmy, and the elementary principles governing in the art of ar.

The military department shall be subject to inspection der the authority of the President of the United States; such spection shall be made, when practicable, near the close of e college year. The inspecting officer shall, upon his arrival the institution, report to the President or other administra-e officer in order to obtain from him the necessary facilities r the performance of his duty. A copy of the report of in-ection will be furnished the President of the institution by War Department.

Military drill has become a feature of all the courses in the iversity, and it is required that all students appear at the ll in uniform. Students are advised to come to the college hout specially providing themselves with new clothes and arrange to wear the cadet uniform habitually while at col-e.

The cost of the uniform is about $14.50. The grade of ing, including the cap, wears well and proves to be eco-ical.

All male students are expected to provide themselves with uniforms. It consists of a blouse, trousers, and cap, after the West Point uniform, with raised gilt buttons.

COURSE IN MILITARY SCIENCE.

Practical.—Cadets are divided into two classes, Fi and Subsequent Year Cadets.

For all cadets: Practical instruction comprises th of the soldier, squad, and company in normal tended order (Infantry Drill Regulations) mounting and guard duty, gallery and rang practice.

For Subsequent Year Cadets: In addition to th comprises artillery drill, saber exercise, and signaling with flag and heliograph.

Theoretical.—Cadets are divided into four classe winter term is especially devoted to this ins which includes the following:

First Year Cadets: Infantry Drill Regulations, i the schools of the soldier, squad, and company mal and extended order.

Second Year Cadets: School of the battalion and nies (Infantry Drill Regulations), and U. S. of Guard Duty.

Freshman Class: "Elements of Military Science,

Sophomore Class: U. S. Army Regulations, mus and returns, etc., Military Law, and State Law ing to the National Guard.

The corps of cadets has this year been divided i companies, with the commandant acting as major. Th ber of young men in the drill has been seventy-seven.

THE LIBRARY.

The library, which is also the general reading room of the Jniversity, is situated on the second floor, in the north wing of he main building. This is a large well-lighted and ventilated partment. The college students use this room during vacant ours from 8:30 a. m. to 12 m., and from 1 to 3:15 p. m.

The students at stated hours during six days of the week, ave access to the books and periodicals. Three volumes may e taken by any one individual and kept from the shelves for a eriod of two weeks. Books reserved at the instance of profes- ors as collateral reading for their courses are shelved in their espective rooms, and can be taken out only on application to ich professors, who are respansible for them during the period f their reservation.

The library contains 9,302 bound volumes, and in addition veral thousand unbound bulletins and reports on agricultural id scientific subjects.

There have been added to the University library during e year 1899-1900, 2,400 bound volumes and 1,000 pamphlets, cluding Experiment Station bulletins and publications from e Department of Agriculture at Washington, D. C.

The Board of Trustees of the University, at its annual eeting in May, 1900, made an appropriation of $5,000 for ref- ence books for the library. The scientific books as pur- ased, after being catalogued, are placed in the reference li- aries in the respective laboratories in the University, the oks for more general use being placed in the library proper. pleasing increase of interest in the library is being shown by students continually; the books are being consulted with eater care, and with results noticeable in the class-room.

The following agricultural papers and Wyoming news- ers are sent to the University:

Arkansas—
  Farmer.

California—
  Press and Horticulturist.
  The Call.
  West American Science.

Colorado—
  Farmer.
  The Field and Farm.

Georgia—
  The Southern Cultivator.

Illinois—
  Prairie Farmer.
  Orange Judd Farmer.
  Farmer's Review.
  The Farmer's Magazine.
  The Elgin Dairy Report.
  Irrigation Age.

Indiana—
  Clover Leaf.

Iowa—
  Iowa Homestead.

Kansas—
  Farmer.

Kentucky—
  The Industrial American.

Louisiana—
  Planter.

Maryland—
  Farmer.
  Southern State.
  Baltimore Weekly Sun.

Massachusetts—
  Farm and Home.
  Ploughman.
  Our Grange Home.
  American Cultivator.
  New England Farmer.

Michigan—
  Grange Visitor.

Missouri—
  National Dairyman.

Nebraska—
  Western Resources.

New Hampshire—
  Mirror and Farmer.

New Mexico—
  Southwestern Farm and Orchard.

New York—
  American Agriculturist.
  Rural New Yorker.
  Sugar Trade Journal.

Ohio—
  American Grange Bulletin.

Ontario—
  Farmers' Advocate.

Pennsylvania—
  Germantown Telegraph.
  Public Ledger, daily.

Virginia—
  Southern Planter.
  The Progressive South.

Washington—
  Northwest Mining Review.

Germania.
Great Round World.
Harper's Monthly.
Harper's Weekly.
Home Study.
Journal of the Society of Chemical Industry.
Journal of the American Chemical Society.
Journal of the British Chemical Society.
Kunkel's Musical Review.
Literary Digest.
Meehan's Magazine.
Metal Worker.
Microscope.
Microscopical Journal.
Mining and Scientific News.
Monist.
Nation.
Nature.
North American Review.
Outlook.
Philosophical Review.
Photographic Times.
Physical Review.
Plant World.
Political Science Montl
Popular Science Montl
Power.
Psychological Review.
Public Libraries.
Quarterly Journal o and Applied Mathe
Review of Reviews.
Science.
Scientific American ar plement.
Scribner.
Sociology.
Studio.
St. Louis and Canadi tographer.
Terrestrial Magnetism
Young Men's Era.
Western Electrician.

The University now uses the Dewey Decimal Ca logue system, and in addition to the regular cards h coming from the Department of Agriculture at Was containing a complete list of publications sent from tha ment and its several branches in connection with the ment Station work.

TREASURER'S REPORT.

THE UNIVERSITY OF WYOMING,
AGRICULTURAL COLLEGE.

Report of the Treasurer of said institution to the governor f the state of Wyoming of amount received under act of Conress of August 30, 1890, in aid of Colleges of Agriculture an he Mechanic Arts, and of the disbursements thereof, to and ncluding June 30, 1900.

alance on hand July 1, 1899		**$12,489.33**
ate of receipt of installment for 1899-1900, Nov. 16, 1899		**25,000.00**
Total available for year ending June 30, 1900		**$37,489.33**

Disbursements thereof for and during the year ending June 30, 1900.

griculture	**$1,729.43**	
echanic Arts	**3,873.42**	
nglish Language	**3,397.88**	
athematical Science	**2,897.95**	
atural or Physical Sciences	**9,739.44**	
conomic Sciences	**4,472.73**	
Total expended during the year		**$26,110.85**
lance remaining unexpended July 1, 1900		**$11,378.48**

Outstanding contracts for facilities not yet delivered, chargeable this unexpended balance, amount to $9,503. Commissioner of Edation. Letter July 12, 1900.

We hereby certify that the above account is correct and ne, and, together with the itemized account attached, truly resents the details of expenditures for the period and by institution named, and that said expenditures were applied ly to instruction in agriculture, the mechanic arts, the Engn language, and the various branches of mathematical, physl, natural, and economic science, with special reference to ir application in the industries of life and to the facilities such instruction.

JOHN C. DAVIS, Treasurer.
GRACE RAYMOND HEBARD, Secretary.

Courses of Study.

For explanation of the Roman numerals, see departm ments on preceding pages. The Arabic numerals indicate of hours a week. Where no numeral appears, 5 is understood. of laboratory, shop or field work are counted as equivalent t of recitation or lecture.

AGRICULTURAL COURSE.

PREPARATORY YEAR.

FALL TERM.	WINTER TERM.	SPRING
History, I. English, I. German, I. Mathematics, I. Industrials, I.	History, II. English, II. Mathematics, II. German, II. Industrials, II.	History, III English, III Mathematic German, II Industrials.

FRESHMAN YEAR.

Physics, I. Mathematics, IV. Drawing, I German, IV. Botany, I English, VII.	Physics, II. Mathematics, V. Drawing, II. German, VI. Botany, II. English, VIII.	Physics, III Mathematic Drawing, II German, V Botany, III. English, IX

SOPHOMORE YEAR.

Zoology, I. Entomology, I. Chemistry, I. English, X, 1. Agriculture, I, 4.	Zoology, II. Entomology, II Chemistry, II. English, XI, 1. Agriculture, II, 4.	Zoology, II Mathematic Chemistry, English, X Agriculture

JUNIOR YEAR.

Geology, I. Philosophy, I. Agriculture, IV. Chemistry, VII. Elective, 5 hours.	Geology, II. Horticulture, I. Agriculture, V. Chemistry, XI. Elective, 5 hours.	Geology, II Horticultur Agriculture Meteorolog Irrigation, Elective, 5

SENIOR YEAR.

Political Science, IV. English, XIX, 1. Elective, 10 hours.	English, XX, 1. Physiology. Elective, 10 hours.	English, X Elective, 15

MECHANICAL COURSE.

For explanation of the Roman numerals, see departmental statements on preceding pages. The Arabic numerals indicate the number f hours a week. Where no numeral appears, 5 is understood. Two hours f laboratory, shop or field work are counted as equivalent to one hour f recitation or lecture.

PREPARATORY YEAR.

FALL TERM.	WINTER TERM.	SPRING TERM.
athematics, I. istory, I. nglish, I. rawing, I. ndustrials, I.	Mathematics, II. History, II. English, II. Drawing, II. Industrials, II.	Mathematics, III. History, III. English, III. Drawing, III. Industrials, III.

FRESHMAN YEAR.

athematics, IV. erman, I. hysics, I. rawing, IV. ndustrials, IV.	Mathematics, V. German, II. Physics, II. Drawing, V. Industrials, V, 8. Mechanics, I, 2.	Mathematics, VI. German, III. Physics, III. Drawing, VI. Industrials, VI. 8. Mechanics, II, 2.

SOPHOMORE YEAR.

athematics, VII. erman, IV. hemistry, I. rawing, VII, 4. nglish, VII, 1. lective, 5.	Mathematics, VIII. German, V. Chemistry, II. Drawing, VIII, 4. English, VIII, 1. Elective, 5.	Mathematics, IX. German, VI. Chemistry, III. Drawing, IX, 4. English, IX, 1. Elective, 5.

JUNIOR YEAR.

athematics, X. echanics, III. lective, 5. rawing, 10, 4. nglish, X, 1. dustrials, VII.	Mathematics, XI. Mechanics, IV. Elective, 5. Drawing, XI, 4. English, XI, 1. Industrials, VIII.	Mathematics, XII. Mechanics, V. Elective, 5. Drawing, XII, 4. English, XII, 1. Industrials, IX.

SENIOR YEAR.

echanics, VI. ective, 5. litical Science. IV. nglish. XIX, 1. dustrials, X. awing, XIII.	Mechanics, VII. Elective, 5. Thesis. English, XX, 1. Industrials, XI.	Mechanics, VIII. Elective, 5. Thesis. English, XXI, 1. Industrials, XII.

UNIVERSITY OF WYOMI

LARAMIE, WYOMING.

Report of the President of Said Institution to the Secret Interior and the Secretary of Agriculture, as Requir of Congress of August 30, 1890, in Aid of Colleges of A and the Mechanic Arts.

RECEIPTS FOR AND DURING THE YEAR ENDING 30, 1900.

1. Balance on hand July 1, 1899, over and above all indebt edness (excluding funded debt, if any)...........
2. State aid: (a) Income from endowment granted by stat
(b) Appropriation for current expenses....
(c) Appropriations for building or for othe special purposes ....
3. Federal aid: (a) Income from land grant, act of Jul 2, 1862 ....
(b) Additional endowment, act of Augu 30, 1890 ....
(c) For experiment stations, act of Marc 2, 1887 ....
4. Fees and all other sources ....

Total ....

EXPENDITURES FOR AND DURING THE YEAR ENDED JUNE 30, 1900.

(Not necessarily a balance sheet as compared with Division II above.)

1.	Instruction in the subjects specified in Sec. 1, act of August 30, 1890*	$18,445.00
2.	Instruction in all other subjects, if any, not mentioned in Question 1 of this series	3,700.00
3.	Administrative expenses (President's, Secretary's, Treasurer's, Librarian's salary, clerical service, fuel light, etc.)**	3,300.00
4.	Experiment Station	15,340.35
	Total	$40,785.35

PROPERTY, YEAR ENDED JUNE 30, 1900.

Value of all buildings, $111,540; of other equipment, $61,500.

Value of above property (an estimate only is expected) not used for instruction in the subjects specified in section 1 of act of August 30, 1890, Buildings (all used); of other equipment, $17,000.

Total number of acres, 416; acres under cultivation, 180; acres used for experiments, 180; value of farm lands, $10,600; amount of all endowment funds, $7,000. (Act July 2, 1862.)

Number of bound volumes June 30, 1900, 9,300; pamphlets, 5,500.

FACULTY DURING THE YEAR ENDED JUNE 30, 1900.

		Male.	Female.
1.	College of Agriculture and Mechanic Arts:		
	(a) Preparatory classes	10	3
	(b) Collegiate and special classes	10	3
	(c) Total, counting none twice	10	3
2.	Number in all other departments (excepting duplicates	3	1
3.	Number of staff of Experiment Station	6	1

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*The answer to this question will include not only the amount received under the act of August 30, 1890 ("Morrill Act"), but also all amounts that are expended for the subjects specified in that act, irrespective of the character of the funds the amounts may be drawn from (State, tuition fees, or endowment, etc.)

**It may be convenient for many institutions to answer 2 and 3 as one question. Cost of new buildings is given under Division I.

STUDENTS DURING THE YEAR ENDED JUNE 30, 190

	Male.	F
(a) Preparatory classes	0	
(b) Collegiate and special classes	15	
(c) Post graduate courses	0	
Total, counting none twice	15	

2. Number in all other departments................90
3. Number of students that pursued courses in agriculture, chanical engineering, 13; electrical engineering, 0; engineering, 11; architecture, 0; household economy, erinary science, 0; military tactics, 66. It is not e that the sum of these figures will equal the number of s given above.)
4. What degrees and how many of each kind were confe 1899-1900?
   On men, 8 (B. A., 3; B. S., 3; M. A., 1; M. Ped., 1).
   On women, 9 (B. A., 2; B. Ped., 7).
5. What and how many honorary degrees were conferred 1900? None.

[Signed] ELMER E. SMILEY,
Presid

.. THE ..

Laramie Cement Plaster.

BY

E. E. SLOSSON AND **R. B. MOUDY.**

(PUBLISHED AS PART OF THE TENTH ANNUAL REPORT OF
THE WYOMING COLLEGE OF AGRICULTURE
AND MECHANICS.)

LARAMIE, 1900.

he Laramie Cement Plaster Industry*

E. E. SLOSSON AND R. B. MOUDY.

There are a large number of gypsum deposits in Wyo- ing varying in composition from pure crystal to gypsite owder. At Red Buttes, since 1889, plaster of Paris and tucco of fine quality have been manufactured, and since 897 the Consolidated Company has been putting on the arket plaster made from the ground gypsum rock. Some sts made on the product of this plant are included in is bulletin and further attention will be paid to it when e gypsum deposits of the state are studied.

The Laramie cement plaster, which is the subject of e investigations here reported, is made from a deposit gypsite just south of Laramie. This bed covers about 0 acres and has been worked by the Standard Cement laster Company since 1896. Their annual output is now out 2500 tons.

THE GEOLOGY OF THE LARAMIE GYPSITE DEPOSIT.†

The Triassic formation, or "red beds" as it is com- only called, which is exposed all along the eastern side the Laramie Plains, contains a great deal of gypsum d one stratum of considerable thickness near the bottom the formation and only a little above the sandstone and estone of the Permian and Carboniferous. This bed as struck in the University artesian well at a depth of

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*This is one of a series of reports issued by various departments of the University on the ral resources of the State and the industries founded upon them. Three bulletins have been ished on petroleum, one on coal, one on mineral in general, one on soda deposit and a large ber on botany and agriculture.

†From information by Professor W. C. Knight.

595 feet and the Permian sandstone at about
The Red Buttes gypsum rock is found in this
and doubtless the gypsum outcrop could be fo
most any point along the eastern side of the Lara
within a half mile of the limestone and sandst
ures which form the western slope of the Lara
tains. The silica and limestone washed down
exposures have mixed with the disintegrated gyp
Triassic beds and have been deposited in depress
plains, forming numerous beds of gypsite or gyp
These deposits can often be detected by the wh
the soil and the peculiar vegetation, which
clumps of grease-wood (*Sarcobatus vermiculatus*
grows on the alkali flats.*

The Laramie gypsite bed has an average
about nine feet. From a few inches below the
about seven feet it is pure gypsite powder, the
red layer of five inches, and below this a foot
the white gypsite powder resting on gravel and
The plaster material is as fine as flour, requiring
ing or even sifting. It is plowed, harrowed a
up, calcined and loaded on the cars.

THE CHEMISTRY OF CEMENT PLASTE

In gypsum four molecules of water of cry
are combined with two molecules of calcium
$2CaSO_4.4H_2O$. This may be regarded as the di-ca
of two molecules of ortho-sulphuric acid, H·O·S.
ing this up to 262°F., according to Le Chatelier
the four molecules of water are driven o
$2CaSO_4.H_2O$. This is the ordinary plaster of

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*According to the California Experiment Station the presence of grea
black alkali (sodium carbonate) in the soil. In Wyoming it is characteristic o
(sodium sulphate), and gypsum where there is no trace of sodium carbonate.

†Thorpe: Dictionary of Applied Chemistry, I. 471.

e principal ingredient in cement plaster. It may be re-
rded as the di-calcium salt of the acid $H_6S_2O_9$ and as
ch would be represented by the symbol $H_2Ca_2S_2O_9$. The
urth and last molecule of water is driven off between 340°
d 381°F., leaving calcium sulphate completely dehy-
rated. Calcium sulphate prepared in this way and not
ated higher than is necessary to completely dehydrate it
kes up one molecule of water very readily, even absorb-
g it from ordinary air,* to form $2CaSO_4.H_2O$, plaster of
ris. If heated still higher to 430°-650°F., or to a red heat,
other change takes place and the calcium sulphate, al-
ough it has the same composition as that prepared at
0°, yet differs from it very decidedly in its properties.
takes up water very slowly, and according to Zulkowski†
ly enough to form $2CaSO_4.2H_2O$. Plaster in this con-
ion is known as "over-burnt" or "dead-burnt," and is use-
s for practical purposes.

The object of the plaster-maker is then to drive off
ee-fourths of the combined water of the gypsum. This
n be done by heating to 340°F., but in practice a tem-
rature of 380-390°F. is used, which doubtless drives off
rt of the last quarter of the water, but this does not mat-
, because, as already said, it is restored by the moisture
the air. The composition of pure gypsum is, then:

cium sulphate	79.1%	100.0	parts
ter	20.9	26.4	
	100.0	126.4	

And of pure plaster of Paris is:

cium sulphate	93.8%	100.0	parts
ter	6.2	6.6	
	100.0	106.6	

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*Potilitzin: Watts' Dictionary of Chemistry, IV. 569.

†Jour. of Soc. of Chem. Ind. XVIII. 918.

Gypsite, or the material from which cement p made, contains beside the gypsum some twenty p other material, such as clay, sand and limesto composition of the different products on the marke variable and cannot be supposed to be alike in th and use, but what difference a greater or less a lime or silica or magnesia has on the working of ter has not been determined. The action of th stances as a whole is to retard the time of settin duce the strength as compared with pure plaster

THE MANUFACTURE OF CEMENT PLASTER AT L

The kettles used in the manufacture of cemen at Laramie hold a charge of about five tons withou over, and the run is made in about three hours.

One run was watched from beginning to end ples taken at intervals for analyses. The results follows:

Time from beginning		Temperature °F	Per Cent Water in Cement	Pounds Water per 100 Pounds Calcium Sulphate	Remarks
hrs.	*min.*				
0	0	65°	32.02	59.93	Charge put in.
2	0	310°	11.69	16.85	Kettle filled.
2	20	320°	9.69	13.66	Boiling.
2	30	340°	• 8.34	12.41	End of first boil.
2	50	390°	6.75	9.17	Dumped.

The gypsite used in this run was quite damp together when squeezed in the hand. To dete amount of moisture, a sample was kept in a desic concentrated sulphuric acid for four months, and samples were heated in test-tubes in a paraffin bath at 65°C. to constant weight.

WATER IN THE GYPSUM EARTH.

1.	Moisture from desiccator sample	15.61%
2.	Moisture from test tube sample	15.89
3.	Moisture from test tube sample	15.65
4.	Water of crystallization in No. 1	19.50
5.	Total water (calculated from Nos. 1 and 4)	32.02
6.	Total water by direct determination	29.95

As the charge of five tons is put in, an operation which lasts about two hours when the material is wet, it sinks to the bottom, but as the temperature increases the powder rises and flows in waves around the kettle as it is stirred by the agitator. The kettle at this stage looks as though filled with a liquid boiling violently. This is due to the expulsion of the water of crystallization. When the first part of the water is driven off the mass sinks down and presents a perfectly smooth and level surface, unbroken by bubbles. As the heat is continued, a second boil begins similar to the first, but shorter, and the thermometer shows a rapid rise of temperature. As the boiling subsides and the temperature is 380-390°F., the operation is complete and the plaster is finished.

By calculating the amount of water present on the constant basis of 100 parts of the calcium sulphate, as is done in the fourth column of the table, we can follow the chemical changes at each stage. We have at the beginning nearly 60 parts water, of which 26.4 is water of crystallization. The first boil consists in driving off the hygroscopic or accidental moisture and part of the water of crystallization. At the end of the first boil the material contains about 13 parts of water per hundred of calcium sulphate, that is, half the original amount of water of crystalization (26.4), has been driven off. If we take the water content as it is falling after the first boil we have which corresponds closely to the theoretical 13.2, c the water of crystallization. From the analysis an the behavior of the gypsite at this point it is very pr we have formed at the end of the first stage of the the monohydrate $CaSO_4.H_2O$, which, however, has n isolated.

At the end of the process we have 9.17 parts wa hundred of sulphate, while theory requires for pla Paris, $2CaSO_4.H_2O$, 6.6, showing that the dehydra not carried quite far enough, and it is probably imp to complete the operation without danger of over some parts.

The cement plaster made in the run just describ the following composition:*

Water	6.93%
Insoluble residue (silica)	5.50
Alumina, Al_2O_3	.59
Lime, CaO	37.11
Magnesia, MgO	1.45
Sulphuric acid, SO_3	43.37
Carbonic acid (by diff.)	5.05
	100.00

These may be combined as follows:

Water	6.93%
Insoluble residue (silica)	5.50
Alumina, Al_2O_3	.59
Magnesium carbonate	3.04
Calcium carbonate	7.86
Calcium sulphate	73.73
Calcium oxide	2.35
	100.00

There was a trace of iron but too small to det It will be seen that there are not enough acids to c with the bases. This fact has also been noticed by Bailey*, who attributes it to the presence of calcium silicate. This is very probable, but this sample gave an alkaline reaction with litmus and turmeric paper, showing the presence of a small amount of free lime, perhaps due to local overheating.

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*Analysis by R. B. Moody.

THE EFFECT OF SAND ON THE CRUSHING STRENGTH.

To determine whether the addition of sand weakens or strengthens the cement plaster, a series of tests was made on two-inch cubes made from the neat cement and cement mixed with amounts of sand running from one-eighth to one and three-quarters the weight of the cement. From six to ten blocks were made of each mixture, as in spite of all efforts to secure uniformity there was a wide variation, as is shown in the table. . This is due apparently to the unequal distribution of minute air bubbles, the presence of which could not be avoided without using too much water or otherwise making the conditions very different from those of practical work.

The sand used was obtained from the Laramie river and was composed of sharp angled granitic fragments. It was sifted through a millimeter sieve. In making the blocks for testing, 400 grams of the cement was weighed out, mixed dry with the weighed amount of sand, then a neasured quantity of distilled water was added to make he mixture of the proper consistency. More water is used or the same amount of cement as the amount of sand is ncreased, but less water in proportion to the total weight f the mixture. After stirring carefully a minute it was oured into the gang moulds for two-inch cubes on a glass late and gently stirred to remove air bubbles. When the laster was set the top was cut down level with the sides of the mold. The tests were made after the blocks ha exposed to the air for one week.

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*University Geological Survey of Kansas, Vol. V.: 163.

The blocks were crushed in a self-registering testing machine, for the use of which we are indeb Prof. W. F. Gilkison. They almost always broke in way as to leave two irregular four-sided pyramid bases at the top and bottom. Since the test block two-inch cubes, the numbers given in the table are divided by four to give the load per square inch, b is not exact, because the compressive resistance o blocks is greater per square inch of surface than fo ones.*

As shown by the table, the cement plaster is the greater the proportion of sand, although indi variations in the strength of the blocks even made the same mixture obscure the relation. The addi 25 percent sand reduces the strength about 15 perce each additional 25 percent of sand decreases the st some 5 percent more.

Cements and mortars can be tested for their ance to tension or compression strains. Both are i ant, but the compression tests are not commonly m account of the greater difficulty and expense. Of th the determination of the compression strength is p ble in the case of mortars* and is of more interest, b so few of such tests are on record. The tensile stre a cement is supposed to be one-tenth its comp strength.

In these tests Laramie cement plaster without re was used.

---

*Behrmann, Rigaer Ind. Leitz., 1899, **25**:27, in Jour. of Soc. of Chem. Ind., 189

TABLE I. *The Effect of Sand on the Strength of Cement.*

Cement Parts by Weight	Sand Parts by Weight	Water Parts by Weight	Crushing Strength of 2-inch Cubes Lbs.	Average Crushing Strength of Each Set of Tests Lbs.
100	0	56.0	5730	5435
			4780	
			5430	
			5810	
100	12.5	56.0	5350	5430
			5570	
100	25	57.0	4410	4575
			4930	
			5350	
			4460	
			4310	
			4580	
			4330	
			4730	
			4360	
			4290	
100	50	58.7	4380	4378
			4440	
			4470	
			4490	
			4110	
100	75	60.0	4390	4317
			4010	
			4590	
			4310	
			4100	
			4290	
			4530	
100	100	61.2	3520	3755
			3490	
			4250	
			3890	
			3930	
			3550	
100	125	62.5	3910	3505
			3220	
			3140	
			3270	
			3760	
			3880	
			3360	
100	150	63.7	3230	3341
			4010	
			3610	
			3190	
			3160	
			3170	
			3190	
			3190	
100	175	65.0	3740	3523
			3230	
			3450	
			3450	
			3790	
			3480	

RETARDERS AND ACCELERATORS.

The setting of plaster of Paris is the revers of its manufacture. The plaster, $2CaSO_4.H_2O$, three molecules of water and forms gypsum, 2Ca The water first dissolves a little of the plaster, crystallizes out from the solution in long need interlace to form a compact mass. The process ta in the course of ten to fifteen minutes for pure pl the mass becomes very warm. The cement plast count of the silica, alumina, lime and magnes tains, sets much more slowly and the heat given slight. The process of setting is much the same case of Portland cement, in which we have, how cium silicate instead of sulphate.

For ordinary plastering the cement plaste quickly and it is always necessary to add some which will keep it workable long enough to use as mixed and to allow time enough for finishing venient portion of the wall. This time varies ac the use made of it and the habits of the workmen customary to make up each lot of cement plaste when it is known exactly what is wanted.

An immense number of different kinds of have been invented and patented.* They are all very much alike in composition and consist esse some organic matter of a gluey nature. All coll as glue, molasses, blood, starch, etc., retard the se crystalloids (salts which crystallize well) accele

The action of retarders is probably to keep cules of dissolved gypsum from uniting togethe tals, as it is well known that the presence of any stance in a solution hinders the formation of a precipitate, and the crystals formed are smaller under such circumstances. If this is true, a retarder must weaken the plaster, because its strength depends on the inter-locking of the gypsum crystals. In all of our experiments we have found that this is the case. From Table IV it will be seen that the addition of 2 pounds per ton, or 0.1 percent of Wymore retarder to Laramie cement plaster reduced the compression strength 25.2 percent, and on Red Buttes cement plaster 2 pounds per ton weakened it 19.6 percent, and 4 pounds per ton 27.6 percent of its original strength. The use of 8 or 10 pounds per ton prevents setting altogether, and the cement remains soft and crumbly. In this case the calcium sulphate takes up the water of crystallization just as before, but the crystals formed are small and separate, and the whole mass is like chalk. 'It is apparent, then, that it should be the object of the manufacturer to use as little retarder as possible, both on account of its cost and because it weakens the plaster. It would be interesting to test a large variety of substances suitable for retarders to see whether they all act equally in diminishing the strength.

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*See list in University Geological Survey of Kansas, Vol V. p. 114.

In the experiments reported in Table II a number of retarders were used to see how they compared in the time they delayed the set. In Nos. 4-8, the retarder used was manufactured in Wymore, Neb., from the tankage from a packing house mixed with limestone. It is of a buff color and has only a slight odor. In 9-12, a retarder from Webster City, Iowa, was used which seems to be the same. The retarder from Swift & Co., Chicago, is of a yellowish brown color, coarsely ground, and has a strong odor. The retarder from Swift & Co., Kansas City, is very course, containing hair, fiber, bone, gravel, etc., very dark in color and has a very strong and disagreeable odor. The odor of wet cement plaster mixed with the last two retarders is so strong and disgusting that it is difficult to marke containing them, although the odor disappears f walls after a few days.

An effort was made to obtain a cheap and hon retarder, and with this in view the cactus which abundantly on the Laramie Plains (*Opuntia pla* was dried and ground.. The common malva (*Ma coccineum*) was prepared in a similar manner, u whole plant. Both these were of a light green c with no odor but that of hay. These were found cellent retarders, nearly as strong as any on the Two pounds per ton retards the setting sufficie practical purposes. It is noticeable, however, that amount does not lengthen the time as much as in of the other retarders.

Clay (Wyoming Bentonite) and dry glucose ar cluded, since they act as retarders.

In making the tests the finely ground retarder curately weighed and thoroughly mixed with the ment. Water was then added and the cement glass plate in a cake four inches in diameter. Two both a twelfth of an inch in diameter, were used mine the time of set. One was loaded with a we quarter of a pound and the other four pounds.. when the lighter needle ceased to make a decided sion on the cake is reported as "first setting," and heavier needle was supported without indentation as "hard set." This method gives results that are ble with each other, though the time given is not rily the same as in actual use, because stirring and the plaster as in using it on walls or for mortar ha setting very much.

Laramie cement plaster, Red Buttes cement agatite, and Red Buttes stucco (plaster of Paris) are included in the tests.

In the case of market samples the amount and kind of retarder is not stated. For these samples, as well as for the information they have given us, we are much indebted to Mr. Wm. McClary, superintendent of the Standard Cement Plaster Works, and Mr. J. B. Arthur, secretary of the Consolidated Plaster Company.

TABLE II. *Effect of Retarders on Time of Setting.*

No	Cement	Retarder	Pounds Retarder Per Ton	First Setting H. M.	Hard Set H. M.	Remarks
1	Laramie	. . . .	0	2:25	3:45	. . . .
2	"	Market sample	Undet.	4:40	5:35	. . . .
3	"	" "	"	. . . .	12:00	. . . .
4	"	Wymore	1	5:20	6:20	. . . .
5	"	"	2	6:05	7:10	. . . .
6	"	"	4	8;40	10:55	. . . .
7	"	"	6	9:50	11:30	Cracked a little
8	"	"	8	13:05	. . . .	Never harden'd
9	"	Webster City	2	5:50	6:30	. . . . [what
10	"	"	4	8:55	10:45	Cracked some-
11	"	"	6	12:15	. . . .	Cracked badly
12	"	"	8	12:35	. . . .	Did not set
13	"	Swift, Chicago	1	4:20	5:10	. . . .
14	"	" "	2	4:25	5:10	. . . .
15	"	" "	4	4:40	5:15	. . . .
16	"	" "	6	4:50	5:20	. . . .
17	"	Swift, Kansas City	1	. . . .	5:10	. . . .
18	"	" " "	2	3:35	4:10	. . . .
19	"	" " "	2	4:15	5:15	. . . .
20	"	" " "	4	4;10	5:15	. . . .
21	"	" " "	4	4:15	5:10	. . . .
22	"	" " "	6	4:10	5:00	. . . .
23	"	" " "	6	3:35	4:15	. . . .
24	"	Cactus	2	4:05	4:45	. . . .
25	"	"	2	4:35	5:20	. . . .
26	"	"	4	4:10	5:10	. . . .
27	"	"	6	4:50	5:40	. . . .
28	"	Malva	2	4:05	4:55	. . . .
29	"	"	4	4:40	4:55	. . . .
30	"	"	6	4:35	5:10	. . . .
31	"	Glucose	6	4:50	6:15	. . . .
32	"	Clay	6	4:00	5:20	. . . .
33	"	"	10	4:20	5:30	. . . .
34	Red Buttes, stucco	. . . .	0	:30	:50	. . . .
35	" " "	. . . .	0	:24	:42	. . . .
36	" " "	. . . .	0	:20	:32	. . . [Cracked
37	" " "	Wymore	8	4:30	. . . .	Did not set.
38	" " "	"	2	1:00	1:45	. . . .
39	" " plaster	. . . .	0	:50	1:20	. . . .
40	" " "	Wymore	2	4:45	5:45	. . . .
41	" " "	"	8	8:25	. . . .	Soft & cracked
42	" " "	Market sample	Undet.	5:10	6:15	. . . .
43	Agatile	Market sample	Undet.	4:00	5:05	. . . .

TABLE III. *Effect of Accelerators on the Time of Settin*

No.	Cement	Accelerator	Pounds per ton	First Settin
1	Laramie	. . . .	0	2:25
2	"	Salt	6	:55
3	"	Sodium Sulphate	6	2:30
4	"	Sodium Carbonate	6	2:25

Accelerators are, of course, not needed in plaster, but it is important to know what substan conditions shorten the time of setting. From Tab appears that common salt, sodium sulphate (glaub and sodium carbonate (sal soda) all accelerate the final setting, and the effect of salt is very decided. ple of Laramie gypsum earth taken in 1898 contai percent sodium sulphate, but that is not found in terial now used.

Of most importance among the accelerators sum itself. If new plaster is mixed in boxes not th cleaned from the old plaster, it will set so quickl is difficult to work. A very small proportion of pl ready set will produce a marked effect.

The use of a large amount of water will delay ting somewhat. Warm water hastens the setti much.

In the manufacture of cement plaster the should be thoroughly mixed with the cold plaste is mixed with the hot plaster just as it comes from tle, as is done in some factories, it is partly melted equally distributed. Ten pounds per ton mixed in does not have so great an effect as two pounds mi

For comparison we have reported in Table IV of tests on the different cement plasters, includin of which we had samples. It will be seen that een said of the weakening effect of sand and retarders olds good for all the brands tested. The crushing strength f the three kinds of cement as marketed, with about same ime of setting, is as follows:

ed Buttes cement plaster, without sand	5200
aramie cement plaster, without sand	4065
gatite cement plaster, without sand	3550

The Red Buttes plaster contained numerous soft spots here the plaster did not set, owing to imperfect burning. hese were not found in the Laramie and agatite plasters.

Since plaster is often mixed by bulk instead of weight, was necessary to determine the relation between the eights and measures, and the figures may be of use to thers. Although the individual particles of plaster are eavier than water, yet a bushel weighs 64 pounds, or 5 percent as much as a bushel of water. A block of the ement plaster after it is set and dry, containing 50 parts nd per 100 parts of plaster, has a specific gravity of 1.5 mpared with water. A cubic foot weighs 93.5 pounds. he sand used had a specific gravity of 1.5 and a ten-quart ıcket holds 29.5 pounds.

TABLE IV. *A Comparison of the Strength of Different*
and Without Retarder and Sand.

Name of Cement	Cement Parts by Weight	Sand Parts by Weight	Water Parts by Weight	Retarder Pounds Per Ton
Laramie plaster	100	0	56	0
Laramie plaster	100	0	56	2
Red Buttes, plaster	100	0	50	0
Red Buttes, plaster	100	0	50	2
Red Buttes, plaster	100	0	50	4
Red Buttes, market sample	100	0	44	Undet
Agatite, market sample	100	0	50	Undet
Red Buttes, stucco	100	0	50	0
Red Buttes, plaster	100	100	55	0
Agatite, market sample	100	100	55	Undet

UNIVERSITY OF WYOMING.

Agricultural College.

TENTH ANNUAL REPORT

. . . OF THE . . .

WYOMING EXPERIMENT STATION,

LARAMIE, WYOMING.

For the Fiscal Year 1899-1900.

Wyoming Agricultural Experiment Station

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*Resigned to accept chair of agriculture in the Colorado ral College, Fort Collins, Colorado. Prof. Luther Foster, M. Logan, Utah, elected to fill vacancy.

TENTH ANNUAL REPORT

. . . OF THE . . .

WYOMING AGRICULTURAL EXPERIMENT STATION.

I hereby submit the tenth annual report for the Wyoming Agricultural Experiment Station, in compliance with congressional enactment. The report covers the work of the station during the fisctl year ending June 30, 1900.

ORIGIN AND PURPOSE.

The Wyoming Agricultural Experiment Station is the department of research of the College of Agriculture of the University of Wyoming. Congress in 1887 appropriated $15,000 annually for this purpose, and on January 10, 1891, the Wyoming legislature authorized the University of Wyoming to receive this appropriation. The work of the station is to aid in the acquiring and diffusing among the people of the United States, and especially of Wyoming, useful and practical information on subjects connected with agriculture, to conduct scientific investigations and experiments on the physiology of plants and animals; to investigate animal and vegetable diseases and parasites; to chemically analyze soils and water and vegetable and animal products; to acclimate grains and grasse fruits and vegetables, to our arid climate and high altitude; t ascertain the best methods of irrigation, and of retaining the moisture in the soil; to find the best breeds of stock, and the best varieties of field and garden crops for the various portion of Wyoming; and to carry on any other experiments whic promise to benefit our agricultural and grazing interes results of these experiments are published in the statio tins, which are sent free upon request to residents of tl

BULLETINS.

Five bulletins have been published during the fis 1899-1900. These bulletins contain pupular account results of such of the investigations by the station as w sidered of especial value to our farmers and ranchme of the technical work as could be prepared is publishe of this report. The detailed accounts of scientific inves are: "The Cryptogams of Wyoming," "Alkali Stu "Variety Tests With Wheat, Oats and Barley," "Son Measurements," Forage Plants," "Germination of W Oats Treated for Smut," and "Meteorology for 189 bulletins are:

No. 41. Some Experiments With Subsoili

This bulletin gives a general account of subsoilin supposed effect of subsoiling on the conservation of for the growth of crops. An experiment which was c three years at Laramie, two years at Lander and She one year at Wheatland and Sundance is reported, e work at Lander, records of which were lost in tran results indicate that subsoiling will pay for root crops doubtful value in raising grain, and that such preparat land does not result in a saving of moisture or decrea cessity of irrigating crops in this region.

No. 42. Some Native Forage Plants for Alkal

A general review of the range areas of the stat and the need of more abundant forage on alkali plains out. Seven of the native Salt or Sweet Sages are desc illustrated with notes regarding the abundance and value of each species. Three grasses, winter fat and one bulrush, which thrive in strong alkali ground, are also discussed. The bulletin shows that the plants are promising species to be brought under cultivation and especially for planting on alkali portions of the farm.

No. 43. ALFALFA AS A HAY CROP.

This report gives a brief history of alfalfa, and instructions for its culture in Wyoming, especially at high altitudes where it has been thought practicable to grow it. The results of nine years' experiments by the Wyoming Station are reported, giving the yield of hay in several parts of the state and an account of the comparative merits of the New Turkestan variety. Accounts are given of the winter killing of alfalfa and the apparent cause; the value of alfalfa for alkali soils, and of the enemies of alfalfa so far observed in the state. The duty of water with fifteen measurements made by the station on alfalfa are also reported, and accounts are given of the success obtained with alfalfa by ranchmen who have tried it on the Laramie plains.

No. 44. ALFALFA AS A FERTILIZER.

This bulletin discusses the need of nitrogen fertilizers for rid soils and the relation of alfalfa to the nitrogen problem, as vell as its effect on the physical condition of the soil. An experiment carried out by the station to show the value of alfalfa s a fertilizer is reported.. It shows that the value of alfalfa ay taken from the land was as great or greater than the value f other crops produced on an adjoining plat of the same size, nd when plowed under the alfalfa having grown on the land ncreased the value of wheat $8 to $12 per acre, oats $16 per cre and potatoes $16 per acre, at no cost for fertilizing the land this manner.

No. 45. A Preliminary Report on the Artesia
of Wyoming.

After a brief introduction setting forth the prima
of the bulletin, a considerable space is given to a resum
oming geology. In this resumé an attempt has been
bring the subject of geology within the reach of the
this state, that they may utilize the data in looking up a
ing artesian conditions. Each formation is briefly
and with the prominent formations there are illustrati
ing the fossils that are usually found in the various
Each formation is also considered from an artesian s
Some space has been given to the discussion of wat
zones, and accompanying this is a table of analyses sh
kinds of water that have been found in some of the
further a tabulated statement showing the general ch
the water found in the various formations. Artesian
mentioned and there is a list of the known wells in
up to the present time. Instructions are given for th
of artesian wells. Following these topics are discussi
various artesian basins. The state has been subdi
eleven artesian basins, and each of these is briefly des
their artesian possibilities discussed. There are also
geological sections to illustrate the structure of the v
sins and a geological map showing the position of
and the geology of each. The bulletin is illustrated
teen plates and fifteen geological sections. While th
possibilities are great in Wyoming, the present de
does not in any way indicate the true conditions. A
wells have been drilled in widely separated localities ;
of these have been carefully located: in fact, the m
them were drilled for other purposes than securin
wells.

Plans of Station Work for 1900-1901.

DEPARTMENT OF AGRICULTURE AND HORTICULTURE.

1. Irrigation investigations.
    - a. Co-operation with the U. S. Department in the measurement of water on farms and in seepage investigations.
    - b. Measurements of water used on experiment farm.
    - c. Plat experiments—different amounts of water on the same crop.
    - d. Notes on sub-irrigation.
    - e. Evaporation from soil.
2. Alkali investigations.
    - a. In the field—Effect of irrigation.
      Effect of green manures.
      Economic plants on alkali soil.
    - b. In the laboratory.
3. Soil work.
    - a. Permanent soil plat—Same crop year after year.
    - b. Crops with and without summer cultivation.
    - c. Crops with and without rotation.
    - d. Alfalfa as a soil improver.
    - e. Fertilizer—Nitrate of soda.
4. Cereals.
    - a. Treatment for grain smut.
    - b. Oats on different depth of plowing.
    - c. Plat work with grains: Best varieties of oats and wheat.

5. Forage crops.
    - a. Cultivated and native, including the co- plats with the U. S. Department of Agricul
    - b. Alfalfa—Different rates of seeding per acre.
    - c. Alfalfa planted with different grasses.
6. Potatoes.
    - a. Different amounts of water used in irrigatio
    - b. Pedigreed potatoes.
7. Horticulture.
    - a. Hardy fruits at Laramie and fruit notes a and Sheridan.
    - b. Garden—small amount of variety work.
    - c. Asparagus on alkali and good land.
    - d. Native trees and shrubs.
    - e. Co-operative experiment in ecology.
8. Pigs on alfafa, artichokes and pease.
9. Entomology.
    - a. Honey bees at Laramie.
    - b. Notes on injurious insects ,collections and e
10. Studies of wheat.

THE BOTANIST.

1. Field work upon the plants of the state continued cial reference to—
    - a. Forage plants.
    - b. Parasitic fungi.
    - c. Edible fleshy fungi.
    - d. Ornamental shrubs.
    - e. Herbaceous perennials suitable for flower ga
    - f. Native fruits.
2. As for 1899, continued.
3. As for 1899, continued.

THE CHEMIST.

1. Effect of alkali on germination of seeds.
2. Analysis of soil and alkali.
3. Analysis of alkali-resisting plants.
4. Analysis of irrigation water.

THE GEOLOGIST.

1. Completion of the preliminary bulletin on the artesian basins of the state.

2. The origin of alkali.
    (1) The geological location of these salts and their relation to the various terranes.
    (2) The way alkali finds its way into the soils.
    (3) Preventing further accumulation if possible.

Wind erosion and its relation to soil formation in the arid districts.

To complete the preliminary work on the birds of Wyoming and arrange notes for publication.

THE PHYSICIST AND METEOROLOGIST.

Movement of alkali in soils.
Evaporation of moisture from the surface of soils.
Effects of mulching the soil to various depths on the evapo ration of moisture.
Study of terrestrial radiation and sunshine.
Observation upon the direction and force of air currents at Laramie.
Continuation of the work of making meteorological observations and co-operating with the state and the United States weather service.

Report of Station Council.

REPORT OF THE DIRECTOR.

The Station Council—What It Is.—The or
purpose of the Agricultural Experiment Station maint
the federal government in connection with the unive
already been explained on a preceding page. It is th
ment of research of the College of Agriculture of the U
of Wyoming. Besides their regular work in the cla
our professors of agriculture, botany, chemistry, phy
geology are also members of the staff on our Station
and are engaged along their several lines of investigatio
nection with the experiment work of this governmen
These five professors of natural science, together
president of the university, who is director of the sta
the secretary of the board of trustees, who is the secreta
station, form the Station Council. This body passes o
ters pertaining to station work in the way of experim
and research, and its recommendations are then referr
agricultural executive committee of the board of trust

All plans of work by the heads of departments are
cussed and accepted, modified or rejected by the Stati
cil; this system insures the co-operation of the staff
workers and prevents scattered work and misappli
Again, all bulletins published by the station are first re
the Station Council and each member is free to cri
questionable point of fact, extravagant statement or th
arrangement of the matter; and finally the bulleti
either adopted and recommended to the Agricultural
Committee of the Board of Trustees for publication.
be returned for revision, or be entirely rejected.

been the general policy governing the station since its organization; and the fact that the workers have been a unit force, and so have made a combined attack on the important agricultural problems from all sides at the same time, has contributed largely to their success heretofore.

What It Does.—The study and research of the station are made as practical as possible, and have to do with the problems which in our opinion are of most importance to the farmers of the state. For example, the subject of irrigation and the alkali problem have been given much attention. At the present time, so far as we can we are co-operating with the Department of Agriculture at Washington in the new irrigation work being done under the direction of Mr. Elwood Mead, who has been for a number of years the efficient State Engineer of Wyoming, and is now connected with the Office of Experiment Stations. The results of our work are being published from time to time. The carefully prepared bulletins, based as they are upon as thorough work as we can do, are offered to the people with the belief that they contain nothing but reliable information, upon which the greatest dependence may be placed.

The widely scattered population of the state has made it almost impossible for the station to come into direct contact with our farmers. The farming communities are naturally located in the places most favorable to agriculture, and are sometimes separated from one another by mountain ranges and long distances; and with the funds at our command and the small number of our station workers it has so far seemed impracticable to do any general farmers' institute work. However, when the time comes that it is possible for us to engage in this kind of work, we shall be glad to undertake it; because we believe it will prove most valuable in bringing the farmers and our station into closer relation with each other. The station workers would then become better acquainted with the farm-

ers' needs, and the information offered by the station
better brought before the attention of the farmers.

The Farm and Buildings.—When the station
inspected by Dr. A. C. True, Director of Experiment
Washington, D. C., he made some valuable suggestio
gard to the enlargement of our experiment farm at
in order that irrigation experiments might be more ex
carried on. Accordingly our original forty acres ha
been increased by a donation of an additional eighty
land, with water right for the same, from the Wyom
tral Land and Improvement company. This land is
to the station to be held so long as it is used for exp
purposes, and fills a long felt want in supplying land
gation on an adequate scale to furnish results of val
arid west. This land has been fenced and forty acre
and putinto crops this year. The station buildings ar
five room cottage, a tool shed, and a shed used as a ba
farm; and a barn and green-house on the university
The farm is well equipped with implements and all ne
chinery. The great need of the station is a good-size
which to store farm implements and grain, and to prov
for threshing and winnowing of seeds indoors.

With only the amount which can be used each
building purposes from the Hatch fund ($750) it is no
to build more than in a very small way, and it would
the state will need to make some provision in the ne
for more commodious buildings for the station. Parti
this true, in case any work is begun in animal industr
then be necessary to add to the buildings at consider
The time has come when it would seem to be necessa
to begin to take some steps in this direction, in orde
the demands of the stockmen in this stock-growing st
here the Director would beg to offer the following su

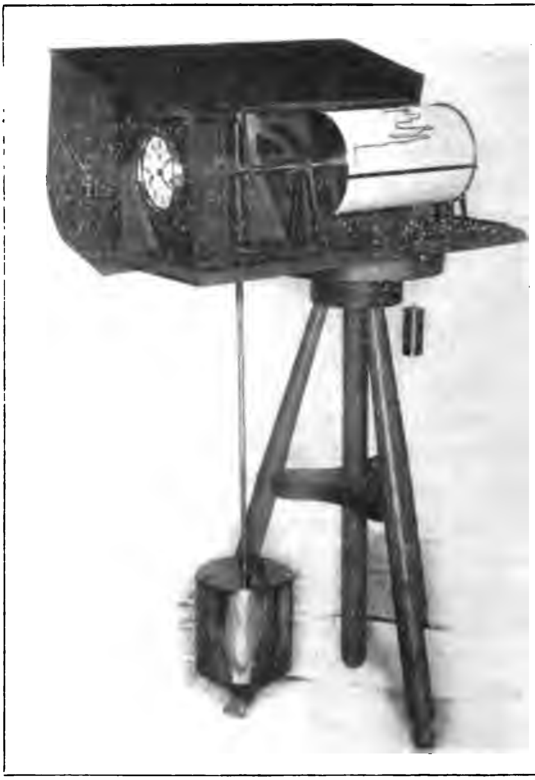
Vhen the vote of the last legislature shall have been carried
nto effect and the present buildings in Laramie now occupied
s a penitentiary shall have been abandoned for the new state
uilding at Rawlins, will it not be practicing a wise economy
or the next legislature to turn over the old grounds and build-
ngs in Laramie to the State Agricultural College of the Uni-
ersity of Wyoming? And by so doing, would not the state
how its good faith in receiving the generous donation from the
ederal government through the Hatch fund?

REPORT OF AGRICULTURIST AND HORTICULTURIST.

The bulletins issued from this department during the year
ere No. 41, "Some Experiments With Subsoiling;" No. 43,
Alfalfa as a Hay Crop," and No. 44, "Alfalfa as a Fertilizer."
'he following special papers have been prepared to accompany
is report: "Alkali Studies V," "Some Water Measure-
ents," "Variety Tests with Wheat, Oats, and Barley," "For-
ge Plants," and "Germination of Wheat and Oats Treated for
mut." The work as planned for the year has been quite fully
rried out. We have continued measurements of water on
e station farm, and in co-operation with the Office of Ex-
riment Stations of the U. S. Department of Agriculture, we
easured the water used on the farms of Mr. C. W. Webber
d Mr. J. W. Sigman. During last August I rated the Lara-
e river with all its tributaries and distributaries from Woods
anding, where the river flows on to the Laramie plains, to a
int below McGill's ranch, where the river leaves the plains.
is work was done under the auspices of the U. S. Depart-
ent, and a report of the same has been made to Prof. Elwood
ead.

Enlargement of the experiment farm enabled us to inaugu-
te some new experiments in irrigation. Eleven acres of the
w land, which lies just south of the original forty-acre plat,

was set aside for investigations of the amount of wa
sary to produce a maximum crop. This plat has be
into three parts and different amounts of water appli
Oats were planted the first year after the sod was br
results of the first year's measurements have been com
give information of much interest. During the ye



pleted a design for a special water register which
larger and more accurate methods of our water me
on the station farm. One of these registers has b

factured for us by W. and L. E. Gurley, and while it did not arrive in time for the first irrigation it will be installed for other measurements of water used on small plats on the farm. This instrument records the actual depth of the water flowing over the weir and the time is represented on a scale of from one-fourth inch to one inch for each hour. The clock which turns the cylinder is provided with the ordinary clock face and hands. A glance will satisfy the observer that the position of the pen on the record sheet corresponds to the clock, which gives a double check on the time. An upright rod from the float is supplied with a sliding scale which can be set at the zero point when the water reaches the height of the base of the weir, and the position of the pen, which is attached to the cord from the float, is adjustable. This gives a double check on the position of the base line and the depth of the water flowing over the weir. These improvements, along with the increased size of the record, insure that accuracy of measurement which is so essential n scientific investigations. The accompanying illustration gives a very good idea of this special purpose register. During he year we also purchased one of the Mead water registers, nd three other instruments were loaned the station from the rrigation investigation section of the Office of Experiment Stations. A Mead nilometer belonging to the station has been oaned for the co-operative experiment station exhibit at the Paris fair.

The alkali investigations have been continued during the ear. The principal field work along this line has been the rowth of economic plants on alkali soil. The Dwarf Essex Rape has succeeded admirably on strong alkali land. This plant s rapidly coming into favor in many sections of the country as stock food, principally for pasturing. Mr. Fairfield, who is ssistant in this department, states that his cow made regular aily visits to that part of the farm during the winter, eating the ape as long as any of it was above ground. The effect on the cream and butter, however, was decidedly unpleasant, would not recommend the plant as a winter pasture cows. In the laboratory an experiment to show the c tive effects of sodium and potassium sulphates and chlo seed germination and plant growth, when the salts were in strengths represented by equal osmotic pressures, ried out. A report of this experiment will be found at of this report, published as "Alkali Studies V."

The permanent soil plat work has been continued tofore and in addition a field experiment on "Alfalfa a tilizer," the results of which were published in Bulletin Work with varieties of small grains was also continued. lieve the four years' tests which have been carried c small grains have given sufficient data, and that it will to reduce the work by eliminating all but the most pr varieties, which seem worthy of larger field trials. F records Mr. Fairfield has prepared a series of tables wh the results of these trials of the varieties of wheat, oats ley. These tables are published as a special paper in co with this report. Some of the Russian grains furnishe Department of Agriculture are promising for this reg pecially two varieties of oats, which gave heavy yields.

The work with forage crops is resulting in data of terest and importance. A report has been made to the of Agrostology on the varieties, seed of which were fu by that Division, and a brief account of the co-operat other work has been prepared for this report. (See " ments with Forage Plants.")

The fertilizer experiment with potatoes was contin season. This was a trial with potassium chloride and s sodium nitrate, and barnyard manure for the improve the potato crop. So far as studied the results are The previous year the salts reduced rather than incre crop of potatoes. Without more favorable results fro rials these commercial fertilizers cannot be recommended for otatoes on the Laramie plains.

Some hardy fruits have been planted at Laramie, and the vork with celery, and pedigreeing potatoes has been cantinued n a small way.

A few insects have been exchanged during the year. A pecial experiment with varieties of wheat at Lander and Sherilan failed at both places. At Sheridan the grains were doing vell when destroyed by hail. At Lander the seed was held in he express office so long that it was too late to plant it when eceived and it was held over till the present season.

The sub-station farm at Lander has been rented to Mrs. arrie B. Meyer, who pays a small cash rental and agrees to ontinue the experimental work with fruits as well as special ials of varieties of wheat. The Sheridan farm has been leased or one year to Mr. A. E. Baker, who also pays a small cash ental and carries on some additional experimental work. This ear Mr. Baker is to report the weather observations, keep notes n the fruits and furnish such reports of the same as may be equired.

The permanent improvements made on the station farm uring the past fiscal year have been as follows: The general ppearance of the farm has been greatly improved by laying out drive past the principal plats and connecting the new part of e farm with the old. Some combined culverts and division tes for water have been put in across these drives and additonal gates for water have been constructed for other places. hich improve the facilities for handling irrigation water. A orm kitchen was built on the farm cottage at a cost of about 25. Two root cellars were constructed, one in connection ith the farm house for the use of the superintendent and a rger one for potatoes, at a total cost for the two of less than 5 for material. The well on the farm was sunk from a depth 168 feet to a total depth of 300 feet. Caving material was passed through at a depth of about 210 feet, making it necessary to case the well before drilling could be continued. A supply of water was obtained, but not yet having passed through the alkali bearing formations (probably Fort Benton), the water is unfit for use. The water was analyzed by Mr. A. H. Danielson, assistant in this department, who found it to contain a total of 7.03 grams salts per liter. Of this amount 1.2 grams is $Na\ Cl$ and 5.7 grams Na_2SO_4. One-half mile from the farm good water was obtained at a depth of less than 200 feet. It is probable we can obtain a good supply by going one or two hundred feet deeper than the present depth of the well.

A tool shed 32 feet by 14 feet in which to store implements was built next to the shed barn. This shed should be improved by battens over the cracks before another winter. A commodious barn building is becoming a great necessity and the present scope of the work can hardly be enlarged until some provision is made for such quarters. The permanent improvement money which can be used from the Hatch fund is so small in amount, being only five percent, or $750 each year, that little can be done with it toward a suitable building, and it seems that it will be necesary for the legislature to make an appropriation for a stock barn. So far as I know, Wyoming is the only state in which the legislature has not aided its experiment station in some such way. The live stock interests are paramount in Wyoming and should receive their share of attention by the station. Before investigation in animal industry can be taken up, it will be necesary that some additional equipment be provided. If Wyoming is to keep in line with sister states she cannot long delay making such provision. Five thousand or ten thousand dollars appropriated by the legislature would erect a suitable stock barn and provide a good water supply.

The general equipment has been increased by the purchase of the water register mentiond above; a boat which can be used for studies of seepage and studies of current meters; a Price current meter for rating streams; a new 6½ x 8½ Korona camera with Turner-Reich convertible lens; a Deering horse rake for the farm; hayfork and elevated cable for stacking alfalfa; New Havana press drill; alfalfa plow; team and harness. One of the horses purchased for the farm died and another horse was obtained. Two teams have been kept very busy through the spring months. During the year a number of new books on agriculture, horticulture and irrigation have been added, and our department collection is now of considerable importance as a working agricultural library.

The work in this department has been actively pursued during the year. The general conditions of the work were quite fully stated in our ninth annual report. We have had more and better help than ever before. Mr. Fairfield has relieved me of the details of the farm work and during the winter has been active in working up crop areas and yields and transferring the day notes to crop record books. This makes them available and puts them into permanent form. The notes and records are more nearly brought up to date than ever before.

Mr. A. H. Danielson, whose services were secured last year, has made himself almost indispensable. He has ably assisted with much of the work of this department and has given considerable time to other things for the institution. He went into the field during the early part of last season to assist with the irrigation. The new farm plats and ditches have been surveyed and platted by him. Under instruction he has cared for the greenhouse work and had charge of the alkali investigations reported as "Alkali Studies V" in this report. He has computed the measurements of water and ratings made in the seepage investigations; has done much typewriting and general office work and relieved me of the larger part of the photograph work which has been done in the office for the station and to meet other demands.

The station has been fortunate in retaining the services of

Mr. E. E. Sigman as farm foreman. He has done the larger part of the team work, relieving Mr. Fairfield so he could give more attention to the taking of notes and general management. Mr. Fairfield has also assisted me by making tabulations, furnishing data from the bulletins which have been published, and made computations from the irrigation register sheets. He also began an experiment in caponizing chickens.

A student stenographer has aided in the office, and while the help during the larger part of the year has not been so efficient as could be wished, it has easily been worth the small amount paid for such services.

In July, I represented the experiment station at the meeting of the American Association of Agricultural Colleges and Experiment Stations, in San Francisco, where I presented a paper giving some of the results of our work in alkali. In September, I was delegate to the National Irrigation Congress, held in Missoula, Mont., where I presented a brief account of our work in irrigation and alkali investigations.

Considering the fact that a part of my time has been given to teaching in the Agricultural College and University, along with faculty and committee work, a comparatively large amount of station work has been accomplished. A number of articles have been written for state and other papers. A series of charts to accompany paper on alkali and a set of photographs were furnished for the Collective Experiment Station exhibit at the Paris fair. An article on horticulture in Wyoming, with a horticultural map of the state, was prepared for the American Cyclopedia of Horticulture. A report on progress of horticulture was sent to the American Pomological Society, of which I am a life member and vice president for Wyoming. I was ably assisted in gathering data for this report by some horticulturists in the state, thanks being especially due Mr. C. A. Manning of Sheridan county, who has taken much interest in the reports for the above society and furnished apples for notes and measurements. Mr. John Gordon of Cheyenne has on two or three occasions sent apples from his Horse creek ranch for determination. So far as we have been able to secure information of apples fruiting in the state at the close of last season, the number, including crabs, reached eighteen varieties.

In closing this, my last annual report for the Wyoming station, I wish to express my appreciation of the kindness and support of the Board of Trustees and the Director, the friendship and willing co-operation of the members of the station staff, and the good counsel and ready help of the Secretary and Librarian. My relations to co-workers in the station and to the people of the state for the nine and a half years of residence have furnished only pleasant recollections which will accompany me to my new field of labor. I find it impossible to adequately express my heartfelt thanks to associates for the many kindnesses which have been extended to me.

REPORT OF THE BOTANIST.

During the year now closing some progress has been made in each of the several lines of work that had been planned for the year, but, on some of these, progress *only* can be reported.

The summer vacation of 1899 was spent in Yellowstone National Park and resulted in a very extensive collection of the native plants—by far the most extensive ever made in that region. Upwards of 1,400 numbers were secured, representing between 20,000 and 25,000 specimens. Of these, the type set (some 1,400 specimens) has been placed in this (The Rocky Mountain Herbarium) herbarium. Of the others, some have been sold to meet the expenses of the expedition, while others have been used in making exchanges to the advantage of the herbarium.

The very considerable number of new species have been published or are in course of publication. Among the papers issued are numbers VIII to XII of the series in the Bulletin of the Torrey Botanical Club, entitled "New Plants from Wyoming." There have also been issued during the year, papers as follows: In Erythea (July), "New Species in Oreocarya and Its Allies;" in Botanical Gazette (Aug.), "Some Species of Tetraneuris and Its Allies;" (Dec.), "Some Rocky Mountain Chyrsothamni;" (Feb.), "A New Violet;" in the Plant World (Mar.), "Popular Ignorance Concerning Botany and Botanists; in Asa Gray Bulletin (April), "Notes Upon the Flora of Yellowstone Park."

One bulletin, No. 42, "Some Forage Plants for Alkali Soils," has been issued from this department.

The investigation of the native fungi, which has had some attention for the past few years, has resulted in the accumulation of a collection upon which may be based a preliminary report. While the collection is far from complete, it gives a fair idea of what parasitic forms flourish under the climatic conditions which previal in this state. Believing that it might be of interest, the other Cryptogams are also included in the annotated list which is published as part of the tenth annual report of the experiment station.

REPORT OF THE CHEMIST.

Most of the work during the year has been the continuation of the study of the effect of alkali on plant life. The previous experiments showed that an important factor in the retardation of the germination of seed caused by alkali was the osmotic pressure of the solution of salts in the soil, and the investigations carried on this year proved that osmotic pressure has the same effect on growing plants.

A number of analyses of soils and alkalies were made during the year and a series of analyses of the water of the Laramie river was made for the Department of Agriculture to determine the increase in alkali content and accumulation of silt by the passage of the river through the Laramie plains.

REPORT OF THE GEOLOGIST.

During the past four summers I have paid special attention to the artesian basins in Wyoming, and as a result of this work I have finished a bulletin entitled "A Preliminary Report on the Artesian Basins of Wyoming. This bulletin comprises about 200 pages, is well illustrated and is also accompanied with a geological map. The map not only portrays the geology of the state but also gives the location of the artesian basins.

In adidtion to my other duties I have spent considerable time in studying and collecting birds. I have on hand at the present time, ample material to publish a bird bulletin. Our collection numbers between 400 and 500 skins. I have secured all of the publications that I can find relating to Wyoming birds and have also collected all other valuable data. The number of birds known to Wyoming is nearly 300 species. The bird bulletin can be published as soon as ordered.

The work on the origin and geological occurrence of alkali in Wyoming has received some attention; but not enough data has been collected to warrant the publication of a bulletin.

For a number of years I have carried on the study of wind erosion and its relation to soil making. These data have been secured while doing other work in various parts of the state. I hope to secure sufficient information during the coming summer to warrant the publication of a bulletin during the year 1901.

My field work for this summer will include the study of wind erosion and its relation to soil making, and the origin of alkali and its geological occurrence.

REPORT OF THE METEOROLOGIST AND PHYSICIST.

Observations in the Meteorological Department have been taken of the relative humidity, maximum and minimum temperatures, pressure of the air, rainfall, snowfall, velocity and direction of the wind, evaporation, percentage of sunshine, and temperature of the soil at various depths. All observations, except amount of rainfall and snowfall, are taken each day at 7 a. m. and 7 p. m.

In the Department of Physics the following are some of the problems which are being investigated as rapidly as circumstances will permit:

Movement of alkali in soils.

Evaporation of moisture from the surface of soils.

Effects of mulching the soil to various depths on the evaporation of moisture.

Study of terrestrial radiation and sunshine.

The following were the most important pieces of apparatus purchased during the year: Sixteen galvanized iron tubes, a portable lantern stand, opaque screen, straight-line diffraction grating, focusing lens, parallel-beam nozzle, apparatus for showing Newton's rings, direct compound prism, photochromoscope, polariscope, model of pendulum clock, two sets of gramme weights, Barker's mill, labial whistle with movable membrane, refraction apparatus, Melonie's apparatus, thermopile, electroscope, apparatus for electrolysis, three Crook's tubes, manometer, twelve burettes, fourteen nests of beakers.

Treasurer's Report.

UNIVERSITY OF WYOMING,
AGRICULTURAL EXPERIMENT STATION,
LARAMIE, WYOMING,
. . . In Account With . . .
THE UNITED STATES APPROPRIATION, 1899-1900.

DR.		
To receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1900, as per Act of Congress approved March 2, 1887	**$15,000.00**	
CR.		
By Salaries		**$ 2,875.00**
Labor		**5,032.76**
Publication		**1,143.53**
Postage and stationery		**383.08**
Freight and express		**316.81**
Heat, light and water		**932.02**
Chemical supplies		**423.58**
Seeds, plants and sundry supplies		**592.57**
Feeding stuffs		**22.00**
Library		**64.09**
Tools, machinery and implements		**363.17**
Furniture and fixtures		**387.44**
Scientific apparatus		**485.58**
Live stock		**300.00**
Traveling expenses		**986.30**
Contingent expenses		**40.82**
Building and repairs		**750.00**
Total	**$15,000.00**	**$15,000.00**

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the University of Wyoming Agricultural Experiment Station for the fiscal year ending June 30, 1900; that we have found the same well kept and classified as above, and that the receipts for the year from the treasurer of the United States are shown to have been $15,000 and the corresponding disbursements $15,000; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving no balance on hand.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2, 1887.

Signed: S. C. PARKS,
HENRY L. STEVENS,
[SEAL] Auditors.

SUPPLEMENTARY STATEMENT.

	Farm Products.	Total.
DR.		
To receipts from other sources than the United States for the year ending June 30, 1900	$340.35	$340.35
CR.		
Traveling expenses	17.71	17.71
Buildings and repairs	322.64	322.64
Total		$340.35

ALKALI STUDIES, V.

By B. C. BUFFUM, M. S., and E. E. SLOSSON, M. S.

PUBLISHED AS PART OF THE TENTH ANNUAL REPORT OF THE
WYOMING EXPERIMENT STATION.

JULY, 1900.

LARAMIE, WYOMING.

Alkali Studies, V.

BY B. C. BUFFUM AND E. E. SLOSSON.

The papers giving results of alkali investigations which have been published heretofore by the Station are Bulletin No. 29; "Alkali," Bulletin No. 39; "Alkali Studies II," "Alkali Studies III," and "Alkali Studies IV," the last two papers being part of the Ninth Annual Report*

Computing the osmotic pressures of the salts in which seeds were germinated and plants were grown, and studies of the imbibition of water from salt solutions, showed that the effect produced was inversely proportional to the osmotic pressure of the salt in solution. This indicated that the effect was a mechanical or physical one; that it would be the same for the same osmotic pressure regardless of the kind of salt, or in other words, that the deleterious effect on plants depends on the osmotic pressure of alkali salt in the soil, rather than on any physiological action of the different kinds of salts. This statement only applies to the neutral salts, and eliminates the sodium carbonate, which has a corrosive action on the plant tissues. Another noticeable effect of the sodium salts when present in small amounts was a stimulating action both on seed germination and the subsequent growth of the plants.

To throw more light on these points experiments† have been carried out on seed germination and plant growth with solutions of potassium and sodium sulphates and chlorides of the same osmotic pressures.

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*See also "Recent Investigations by the Wyoming Experiment Station in Alkali and Irrigation," published in the Proceedings of the Thirteenth Annual Convention of the Association of American Agricultural Colleges and Experiment Stations, p. 60.

†Mr. A. H. Danielson has ably assisted with this experiment by carrying out the details as planned.

SALT SOLUTIONS USED.

The salts used in the experiments were sodium sulphate and sodium chloride, and potassium sulphate and potassium chloride. A series of these solutions were made which had the same osmotic pressures. Knowing the effect produced by sodium sulphate in previous experiments, this salt was taken as the arbitrary base, using it in strengths of 0.5 percent, 1.0 percent, and 2.0 percent solutions, which are common concentrations in Wyoming alkali soils. These percents of sodium sulphate in solution gave corresponding osmotic pressures of 2.03 atmospheres, 3.80 atmospheres, and 7.10 atmospheres. The following table gives the precent of each salt used to produce the same osmotic pressure as above:

TABLE 1—*Osmotic Pressure an.l percent of Salt.*

Osmotic Pressure in Atmospheres.	2.03	3.80	7.10
	percent	*percent*	*percent*
Na_2SO_4	0.50	1.00	2.00
K_2SO_4	0.67	1.32	2.51
Na Cl	0.27	0.51	0.96
K Cl	0.33	0.64	1.22

GERMINATION OF SEEDS.

Wheat and alfalfa were selected as one cereal and one legume to germinate in the above solutions. Granite iron pie plates were used, in each of which was placed 850 grams of sand, which had been washed free from soluble salts. On each plate was placed a layer of sand in which the seeds were embedded. They were then covered with pieces of thin cheese-cloth, over which the remaining sand was placed.* This enabled the upper layer of sand to be removed in order to count the seeds as they germinated. To each of the plates so arranged was added 150 c. c. of solution containing the salt with osmotic pressures of about 2, 4, and 7 atmospheres as given in table I. The sand was dried, so the solution added gave 15 percent moisture to each plate. As it is the salt in solution which affects the seed or plant, there would be no dilution by the sand, i. e., the same osmotic pressure of salt would be present regardless of the amount of sand. However, the evaporation of the water from the plates would increase the strength of the salts and precautions were taken to prevent this so far as possible. They were placed in a copper germinating chamber, which was kept closed except during the time the seeds were being counted. Each plate was weighed after adding the solutions and distilled water added each day to replace that which had evaporated. One hundred seeds each of wheat and alfalfa were planted in each plate on March 28, between 3 and 4:30 o'clock p. m. The first counting of the germinated seeds was made 48 hours after they were planted. Table II gives the result with wheat and Table III with alfalfa seed. The first column gives the number of hours from the time of planting. The other columns give the number of seeds germinated in the different strength solutions of each salt.

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*A careful study was previously made of the effect of such pieces of cheese-cloth on the movement of alkali salt through the sand. Several trials in which alkali solutions were added to sand which was separated into layers by the thin muslin; allowed to stand about a week and then analyzed, showed practically no difference in the amount of alkali in any part of the sand above re below the dividing layer of cloth.

A study of the tables shows that the retarding effect of the salts on germination of wheat and alfalfa is almost identical in each series of salt solutions. There are only slight variations, such as might be expected in any two or more sets of seeds germinating under conditions which are practically the same. There is a remarkably regular decrease in the germination of the seeds as the osmotic pressure increases, but there is no apparent difference between the effect of sodium and potassium nor between sulphates and chlorides either of the same or of different salts. This strengthens the conclusion reached in previous experiments, so far as seed germination is concerned, that the retarding effect is due to the osmotic pressure of a salt rather than to the kind of salt. The strongest solution of potassium chloride apparently retarded the germination of both wheat and alfalfa seed less than the same strength of the other salts used, but the difference is only slight and can not be taken as conclusive evidence that this salt does not produce the same general effect.

TABLE II—*Germination of Wheat.*

Percent of seed germinated.

Salt	None H_2O	Na_2SO_4			Na Cl			K_2SO_4			K Cl		
Pressure in atmospheres	00	2.03	3.80	7.10	2.03	3.80	7.10	2.03	3.80	7.10	2.03	3.80	7.10
Hours													
48	94	91	81	44	91	80	43	80	84	25	91	86	73
72	98	93	93	90	99	92	87	96	94	88	94	89	95
96	99	98	96	94	100	93	95	98	96	94	96	91	95
120			97	95		95	96	97		98	97	92	97
144				96		97			97			94	
168			98										98
209													
260													

TABLE III.—*Germination of Alfalfa.*

Percent of seed germinated.

Salt	None, water	Na_2SO_4			Na Cl			K_2SO_4			K Cl		
Pressure, atmospheres	0.0	2.03	3.80	7.10	2.03	3.80	7.10	2.03	3.80	7.10	2.03	3.80	7.10
Hours													
48	86	70	36		87	75	14	79	66	12	88	78	52
72	98	88	89	28	94	94	74	94	93	88	96	91	92
96		96	97	75	97	98	99	97	97	98	98	97	96
120		97	98	81			100				99		99
144			99	91						97			
168				94									
209				96									
260													

As in the experiments previously published, the effect of salts in solution is to retard the time of germination. The percentage of seeds finally germinated in the salt solutions is as great as in pure water. The retardation of some five or six days may appear of no practical importance, but the growing season is so short at high altitudes that even a few days may make the difference between a crop and a failure.

GROWTH OF WHEAT AND ALFALFA IN SODIUM AND POTASSIUM SALTS OF THE SAME OSMOTIC PRESSURE.

The same solutions were used as in the germinating test reported above. The plants were grown in clean river sand free from soluble salts and enough solution added to make fifteen percent moisture present. When saturated, this sand held eighteen percent water. The sand was analyzed for potash and found to contain 3.566 precent K_2O, none of which is supposed to be available to plants.

POTS.—Previous attempts had demonstrated that it was not feasible to use alkali salts in porous pots, as the evaporation of water left the pots incrusted with salts, which left unknown quantities of salts in the soil.* Plants are not apt to succeed well if grown in pots which have no drainage or ventilation. Inquiries were made of Prof. H. J. Wheeler of Rhode Island, who has made a study of the kinds of pots best to use for seed experiments, and we adopted his suggestion except that we used glazed earthenware pots instead of iron ones. Having made some trials, it was found that the salts used would have no appreciable effect on the glazing of the jars.

The suggestion by Prof. Wheeler, of method of ventilating the pots, was a good one. Pieces of stove-pipe iron were bent into half cylinders, and cut into lengths which would fit across the bottom of the jars. These irons were punched full of small holes, to provide drainage from the sand into them, and at each end a larger hole was made in the top, over which half inch glass tubes were placed.

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*See photograph on p. 32 of Alfalfa Studies III, Ninth An. Report.

These tubes extended up through the sand, and one of them was five or six inches longer than the other, so it acted like a chimney, producing a draft of air down the short tube and out the longer one, removing any surplus moisture collecting in the cavity produced by the iron half-cylinder at the bottom. That they were operating as they should could be seen at a glance in the mornings, as drops of condensed moisture would collect in the top of the longer tube, while the shorter one was always dry. As the water passed out in the form of vapor, all the salt was left in the pots. Each pot with its sand and solution was weighed and at intervals distilled water was added to take the place of that lost by evaporation from the air drainage, surface of the pots and transpiration by the plants.

NUTRITIVE SOLUTIONS.—After studying the nutritive solutions given by botanical authorities, the following combinations were used:

NO. 1. For the Sodium salts.		NO. 2. For the Potash salts.	
KNO_3	1.0g	$Na NO_3$	0.8g
$Ca (NO_3)_2$	0.5	$Ca(NO_3)_2$	0.5
$Mg SO_4$	0.5	$Mg SO_4$	0.5
Bone Meal	2.0	Bone Meal	2.0

In No. 2 less of the sodium nitrate was used than of the potassium nitrate in No. 1, because the sodium nitrate has a greater osmotic pressure and the attempt was made to make them of as nearly the same pressure as possible. Instead of calcium phosphate or acid potassium phosphate, 2 grams of raw bone meal was used in each solution, as the bone meal contained the phosphates and a small amount of organic nitrogen as well.

The above amounts of nutritive salts were added to the five kilograms of sand in each of the pots. To the nutritive solution was added the percents of salts which would

PLATE I.

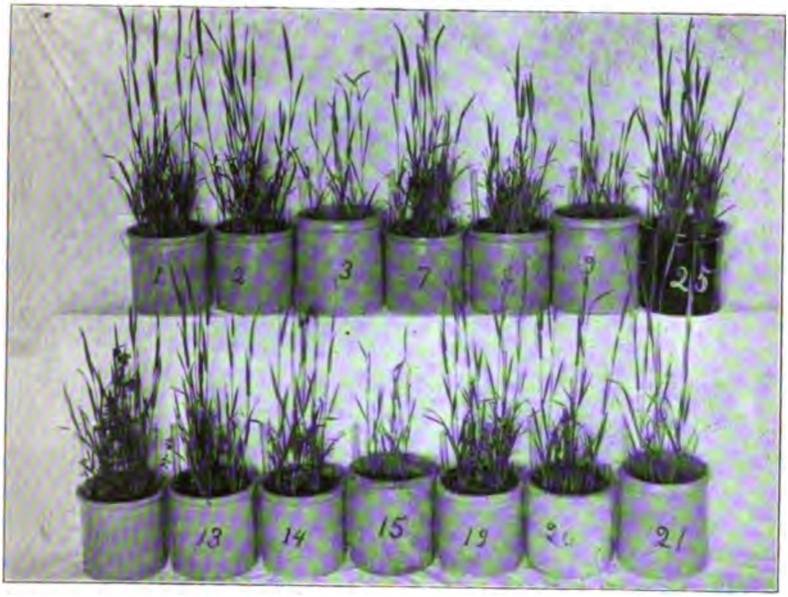

FIG. 1. Wheat, in alkali solutions, June 10, 1900.

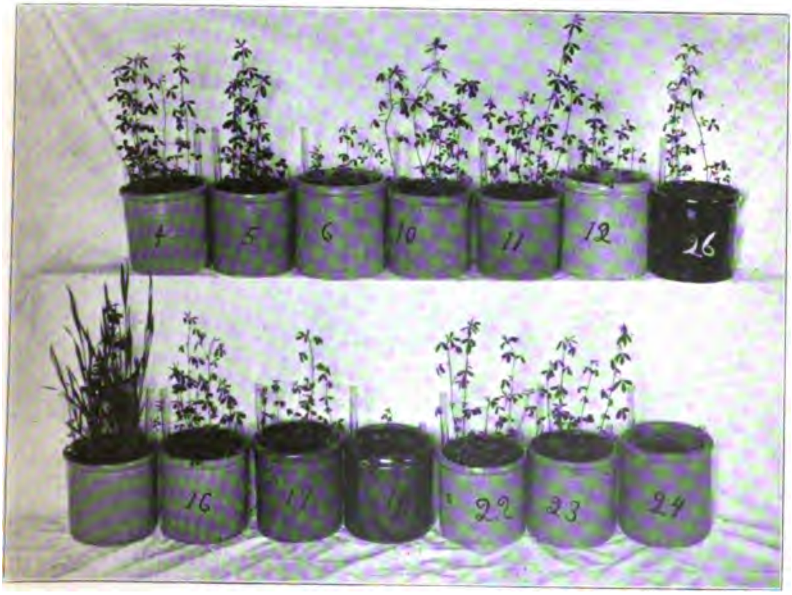

FIG. 2. Alfalfa, in alkali solutions, June 10, 1900.

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PLATE II.

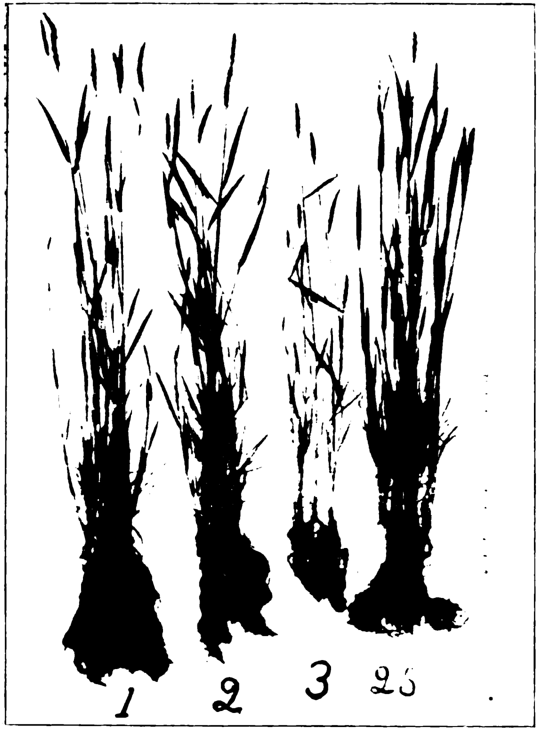

FIG. 3.—WHEAT.

No. 1.—Grown in Na_2SO_4 of 2.03 osmotic pressure.
No. 2.—Grown in Na_2SO_4 of 3.80 osmctic pressure.
No. 3.—Grown in Na_2SO_4 of 7.10 osmctic pressure.
No. 25.—Grown in check of 0.00 osmotic pressure.

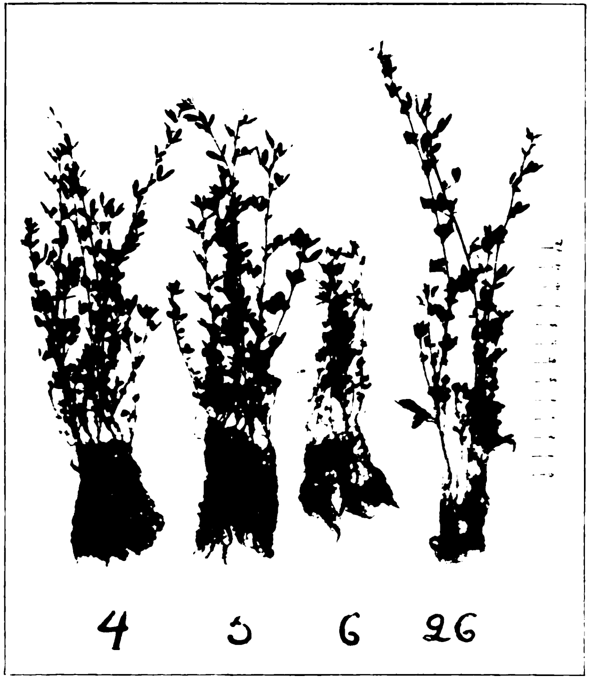

FIG. 4.—ALFALFA.

No. 4.—Grown in Na_2SO_4 of 2.03 osmotic pressure.
No. 5.—Grown in Na_2SO_4 of 3.80 osmotic pressure.
No. 6.—Grown in Na_2SO_4 of 7.10 osmotic pressure.
No. 26.—Grown in check

PLATE III.

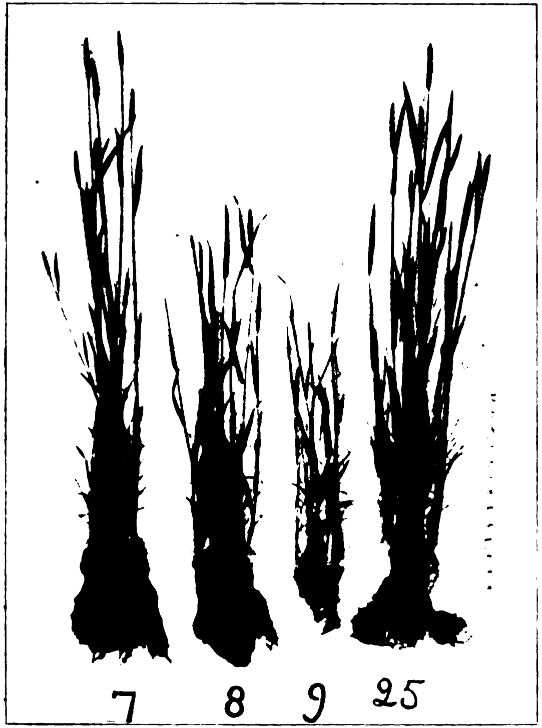

FIG. 5.—WHEAT.

No. 7.—Grown in K_2SO_4 of 2.03 osmotic pressure.
No. 8.—Grown in K_2SO_4 of 3.80 osmotic pressure.
No. 9.—Grown in K_2SO_4 of 7.10 osmotic pressure.

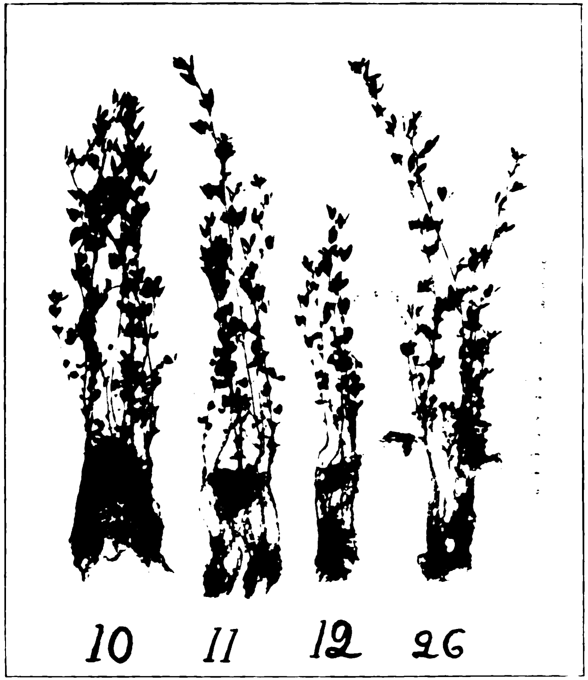

FIG. 6.—ALFALFA.

No. 10.—Grown in K_2SO_4 of 2.03 osmotic pressure.
No. 11.—Grown in K_2SO_4 of 3.80 osmotic pressure.
No. 12.—Grown in K_2SO_4 of 7.10 osmotic pressure.

PLATE IV.

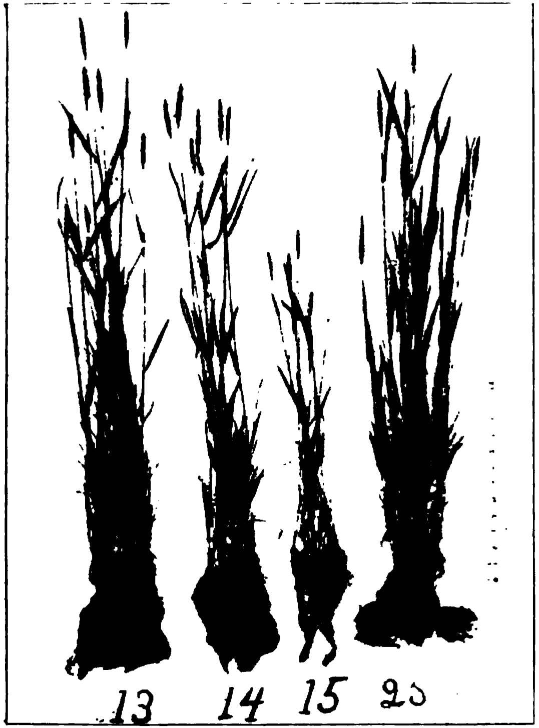

FIG 7.—WHEAT.

No. 13.—Grown in Na Cl of 2.03 osmotic pressure.
No. 14.—Grown in Na Cl of 3.80 osmotic pressure.
No. 15.—Grown in Na Cl of 7. 10 osmotic pressure.
No. 25.—Grown in check of 0.00 osmotic pressure.

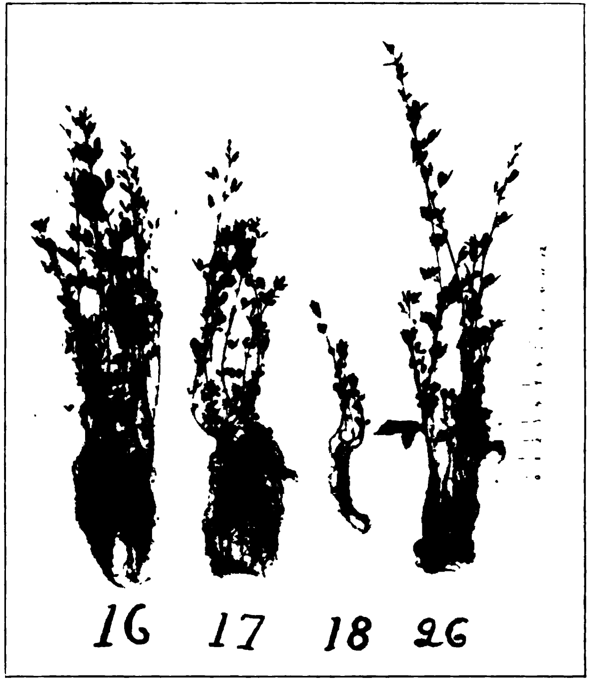

FIG. 8.—ALFALFA.

No. 16.—Grown in Na Cl of 2.03 osmotic pressure.
No. 17.—Grown in Na Cl of 3.80 osmotic pressure.
No. 18.—Grown in Na Cl of 7.10 osmotic pressure.
No. 26.—Grown in check of 0.00 osmotic pressure.

PLATE V.

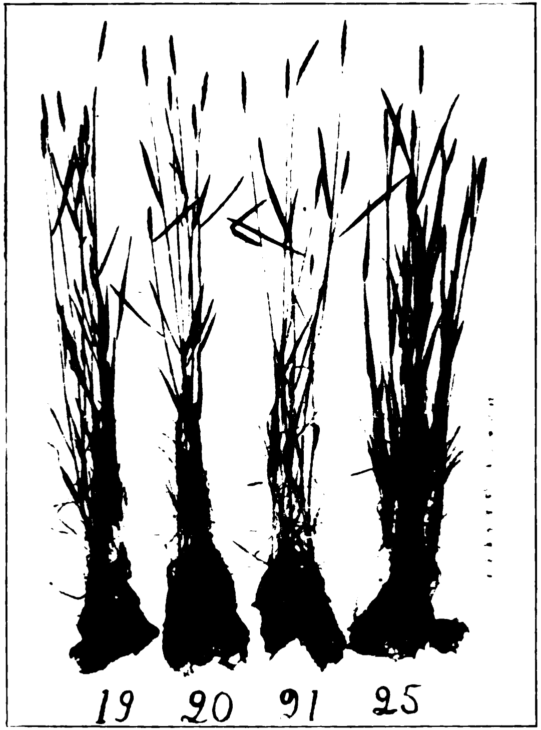

FIG. 9.—WHEAT.

No. 19.—Grown in K Cl of 2.03 osmotic pressure.
No. 20.—Grown in K Cl of 3.80 osmotic pressure.
No. 21.—Grown in K Cl of 7.10 osmotic pressure.
No. 25.—Grown in check of 0.00 osmotic pressure.

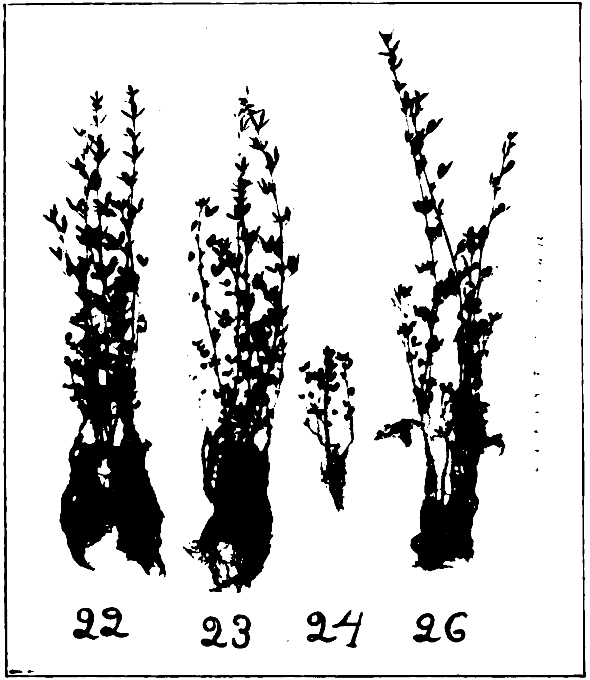

FIG. 10.—ALFALFA.

No. 22.—Grown in K Cl of 2.03 osmotic pressure.
No. 23.—Grown in K Cl of 3.80 osmotic pressure.
No. 24.—Grown in K Cl of 7.10 osmotic pressure.
No. 26.—Grown in check of 0.00 osmotic

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produce the different osmotic pressures, so the pressure was increased above the computed amount by the pressure of the nutritive salts added, but the increase of pressure due to the nutritive solution is too small to take into consideration. Enough of the combined solution was made up for each pot to give fifteen percent moisture. Two check pots were supplied with nutritive solution and water only and one was given double the amount of nutritive solution as an indication of whether the right amount of nutrition was supplied. About fifteen seeds of wheat were planted in each of one series of pots and twice as many seeds of alfalfa in the other series, which contained the same strengths of the salts being studied. The seeds were planted March 22, between 3 and 4 o'clock p. m.

In the pots which contained double the amount of nutritive solution the wheat and alfalfa were allowed to grow together. This is the pot not numbered shown on the left and at the bottom of Figs. 1 and 2, Plate I. The plants grew no better than those which had only the single strength of nutritive salts. See pots No. 25 and No. 26 in the same illustration.* On April 7, after the plants came up and had developed the first two leaves, the weaker ones were pulled out, leaving only six plants in each pot. In one or two instances a seed which was slow in coming up developed later, which accounts for seven stools in some of the pots at the time they were harvested.

The illustrations, Plates II to VI, show the comparative growth of the plants at the time they were harvested on June 25. Tables IV and V give the numbers of the pots, the corresponding osmotic pressures in atmospheres, and comparative notes on growth, and weight of plants harvested, both green and dry matter, and Table VI gives the sulphates and chlorides taken up by the plants in each case.

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*Photograph from which Plate I was made was taken June 10.

All the salts in weaker solutions produced a stimulating effect on the growth of both wheat and alfalfa. The decrease is quite regular with increase in osmotic pressure with all the salts used except potassium chloride, which retarded growth much less than the other salts. With pressure of 3.8 atmospheres the K Cl forced alfalfa into bloom earlier than the other pots. Its fertilizing effect is marked except in the strongest solution with alfalfa, where the retarding effect is as great or greater than that of any of the salts of the same concentration.

TABLE IV.—*Wheat. Comparative growth in salt solutions of equal osmotic pressures.*

SOLUTION.	No. of pot	Osmotic pressure	Height April 11	Height June 11		June 25. Harvested						Weight of plants	
				Highest stalk	Average	Highest stalk	No. of stools	No. of stalks	No. of heads	No. heads in bloom	Heads in boot	Green	Dry
		atmos	*inch's*	*inch's*	*inch's*	*inch's*						*grams*	*grams*
Water	25	0.0	7.3	19.2	15.0	30.7	6	25	6	5	7	34.15	14.067
Na_2SO_4 . .	1	2.03	5	19.8	19.1	33.0	6	24	8	6	4	36.51	12.453
	2	3.80	5	22.2	19.5	30.0	7	22	8	8	3	36.44	12.435
	3	7.10		17.0	14.0	25.5	7	9	5	5	1	19.42	6.838
K_2SO_4 . .	7	2.03	7.3	23.0	17.5	32.0	7	23	10	7	1	34.81	10.914
	8	3.80	7.3	17.5	9.5	22.5	6	19	2	1	5	19.97	6.895
	9	7.10		16.5	9.0	20.5	8	11	0	0	3	7.13	2.856
Na Cl . . .	13	2.03	6.5	22.0	17.0	32.0	6	24	11	5	2	36.13	12.872
	14	3.80		20.2	20.0	29.5	6	17	6	6	1	21.26	7.954
	15	7.10	5.5	15.5	12.5	19.0	6	6	6	3	0	7.28	2.730
K Cl . . .	19	2.03	7.3	22.6	16.5	32.7	5	17	6	6	4	27.54	10.100
	20	3.80	6.8	20.5	18.0	31.5	6	19	6	6	0	19.69	7.761
	21	7.10	8.0	24.0	21.5	33.7	6	13	7	6	0	15.58	7.642

The daily notes taken June 11 state that the best three pots of alfalfa were 10, 11 and 12, or those in potassium sulphate, and 19, 20 and 21, containing potassium chloride, were the best three pots of wheat, though 1, 2 and 3 in sodium sulphate were almost equal in thriftiness and growth, and previous notes stated that to all appearances the sodium sulphate was less injurious when in excess than the potash salts.

TABLE V.—*Alfalfa. Comparative growth in salt solutions of equai osmotic pressures.*

SOLUTION	No. of pot	Osmotic pressure	Height April 11	Height June 11		June 25					Weight of plants	
				Highest	Average	Highest stalk	No. of stools	No. of stalks	No. stalks budded	No. in bloom	Green	Dry
		atmos	*inch's*	*inch's*	*inch's*	*inch's*					*grams*	*grams*
Water	26	0.0	*	15.0	10.0	20.5	6	11	3	0	10.20	4.6345
Na_2SO_4. . . .	4	2.03	1.0*	15.5	9.0	18.5	7	14	2	0	26.14	9.5251
	5	3.80	†	14.0	8.0	18.0	7	11	4	0	22.90	7.2593
	6	7.10	†	6.0	4.5	8.5	8	12	0	0	8.16	2.2724
K_2SO_4	10	2.03	1.2*	17.0	12.0	19 0	6	13	2	0	23.07	7.7098
	11	3.80	1.2*	18.5	9.0	22.06	7	9	4	0	16.52	5.1225
	12	7.10	1.2*	10.2	7.0	13.0	6	8	0	0	4.75	2.2504
Na Cl	16	2.03	*	13.0	8.5	17.5	6	17	4	0	23.18	6.7620
	17	3.80	†	12 0	7.2	15.5	6	9	1	0	12.70	3.7168
	18	7.10	†	5.0	2.8	6.7	5	5	0	0	1.95	0.6960
K Cl	22	2.03	*	13.0	8.5	18.0	7	16	3	0	14.23	4.9499
	23	3.80	*	13.5	9.5	19.0	6	7	5	2	13.42	4.7085
	24	7.10	†	2.5	2.0	4.5	5	5	0	0	1.76	0.5189

*Second leaves developed. †Only the first seed leaves developed.

In discussion of fertilizers, attention has been too exclusively confined to the chemical effects and the physical action of the salts in the soil water from which the plant draws its food, and water has been generally disregarded. If the addition of a salt to the soil stimulated the growth it was supposed to be because it supplied a needed food element; if it injured the plant it was held to be poisonous.

From the standpoint of the modern theory of solutions, however, the whole question of the action of fertilizers must be restudied both experimentally and theoretically. We now know that the absorption and movement of food material in the plant is largely controlled by osmotic pressure and that some of the cell walls act like semi-permeable membranes permitting the free passage of water but preventing or hindering the passage of salts and other matter in solution. A substance dissolved in water acts just like a gas. It tends to expand, that is, to increase the space it occupies. This may be done in two ways. If nothing prevents , the substance in solution spreads through the whole liquid until it is evenly diffused. If a semi-permeable membrane prevents the passage of the dissolved substance through all the water, it may still expand if water can be drawn through the membrane, thus enlarging the space which it can occupy. If this is prevented a pressure on the membrane results, the osmotic pressure, which is identical in nature and amount with gas pressure. Solutions always tend toward homogenety, either by the dissolved substance passing from parts of greater concentration to those of less or by the solvent moving in the reverse direction.

In the previous experiments of this series it was shown that the absorption of water by seeds was hindered by the osmotic pressure of the solutions in which the seeds were placed, that various salts and sugar in widely different amounts produce the same effect if their osmotic pressure was the same and that seeds in which the power of germination had been destroyed and even wood were affected in the same way as living seeds. The present experiments extend the study to germination and the growing plant, and it appears that the osmotic pressure of the solution in which the plant is placed tends to prevent its growth by hindering the absorption of water. This effect is so great as to entirely overshadow the nutritive action of the different salts and excess of potash salts is shown to be quite as bad as excess of sodium salts.

As the experiment had a practical aim, the study of plant growth in the arid regions, the conditions were chosen to imitate those found in nature and are not such as would otherwise have been selected in a purely scientific study in plant physiology. In the soils of the arid region we have, as we have in these pot experiments, a nutritive solution containing all the necessary plant foods but accompanied with a large excess of some particular salt, usually sodium sulphate, magnesium sulphate or sodium chloride. From the results given in the tables and illustrations it appears that the effect of a large excess of any salt in the soil is to hinder the growth of plants and that the osmotic pressure of the solution is an important factor in producing this result. It is not to be supposed that the effect is a simple one. On the contrary, the presence of a large excess of some salt must not only increase the osmotic pressure, but also change the conditions of assimilation of plant food in many ways and disarrange the nutritive system of the plant.

ABSORPTION OF SALTS FROM SOLUTIONS.

In order to determine in how far the salts in excess were absorbed by the plants, they were analyzed for chlorides or sulphates and the results are given in Table VI. It will be seen that in the case of both sulphates a greater amount of the salt was taken up by the plant the more concentrated the solution. In the case of the chlorides, on the contrary, the normal amount in the plant was not increased but actually diminished by the increase in the concentration of the solution. In the previous experiments on the absorption of salts by seeds no such difference between sulphates and chlorides was found and it is perhaps due to the fact that sulphur is of more importance as a plant food than chlorine.

TABLE VI.—*Salts absorbed by plants.*

No.	Plant	Salt	Percentage	Osmotic pressure, atmospheres	Percentage of salt in the air-dried plant
26.	Alfalfa . .	. . . .	. . . .	. . . .	.49 sodium sulphate .67 potassium sulphate
4.	“ . .	Sodium sulphate. . .	.50	2.03	1.49 sodium sulphate
5.	“ . .	“ “ . . .	1.00	3.80	2.33 “ “
6.	“ . .	“ “ . . .	2.00	7.10	5.20 “ “
10.	“ . .	Potassium sulphate .	.67	2.03	2.57 potassium sulphate
11.	“ . .	“ “ .	1.32	3.80	3.47 “ “
12.	“ . .	“ “ .	2.51	7.10	5.07 “ “
16.	“ . .	Sodium chloride . . .	.27	2.03	.41 sodium chloride
17.	“ . .	“ “ . . .	.51	3.80	.19 “ “
18.	“ . .	“ “ . . .	.97	7.10	.10 “ “
22.	“ . .	Potassium chloride. .	.33	2.03	.28 potassium chloride
23.	“ . .	“ “ . .	.64	3.80	.26 “ “
24.	“ . .	“ “ . .	1.22	7.10	.13 “ “
25.	Wheat. . .	. . . .	. . . .	. . . .	.83 sodium sulphate 1.14 potassium sulphate
1.	“ . . .	Sodium sulphate. . .	.50	2.03	.80 sodium sulphate
2.	“ . . .	“ “ . . .	1.00	3.80	1.90 “ “
3.	“ . . .	“ “ . . .	2.00	7.10	2.24 “ “
7.	“ . . .	Potassium sulphate .	.67	2.03	2.16 potassium sulphate
8.	“ . . .	“ “ .	1.32	3.80	3.30 “ “
9.	“ . . .	“ “ .	2.51	7.10	14.97 “ “
13.	“ . . .	Sodium chloride . . .	.27	2.03	3.14 sodium chloride
14.	“ . . .	“ “ . . .	.51	3.80	2.29 “ “
15.	“ . . .	“ “ . . .	.97	7.10	.80 “ “
19.	“ . . .	Potassium chloride. .	.33	2.03	2.12 potassium chloride
20.	“ . . .	“ “ . .	.64	3.80	1.80 “ “
21.	“ . . .	“ “ . .	1.22	7.10	1.71 “ “

In Nos. 25 and 26, plants grown in nutritive solution alone, the sulphuric acid actually determined is calculated both as potassium and sodium sulphates for comparison.

EVAPORATION OF WATER FROM THE SALT SOLUTIONS AND PLANTS GROWING THEREIN.

Table VII gives the amount of water added to each pot to take the place of that lost by evaporation and bring it back to the initial weight, which was carefully determined at the beginning of the experiment. The amount is given in grams, each date water was added, the average amount evaporated each day being shown in the last column. The increase in the evaporation during June is due to the increased amount of water thrown off by the plants as they grew larger in size. The wheat produced more weight of plant in the nutritive solution alone than in any of the salt solutions and in every case less water was lost by evaporation and transpiration in the salt solutions. On the other hand, the alfalfa produced more weight of plant in the weaker salt solutions and more water was lost from these solutions than from the nutritive solution alone. With the exception of the wheat in K Cl solutions, there is quite a regular decrease in the amount of water evaporated as the pressure of the salt increased. This is due both to the difference in the size of the plants produced and to the increase in pressure. Averaging the amounts of water added to each pot up to and including April 11, while the plants were small and before there was marked difference in them as they grew in the several pots, gives no results from which conclusions can be drawn. In general there was greater evaporation from the check pots than from those containing salts. The loss of water by evaporation would increase the osmotic pressure of the solution remaining, so the mean strength of each solution for the entire experiment is somewhat greater than the indicated concentration of the solutions used.

Planted March 24.

TABLE VII.—*Evaporation from pots with alkali salts.*

Pot No.	Salt	Plant	Strength in atmospheres	Water added March 24	March 28	March 30	April 2	April 5	April 7	April 11	April 16	April 20	Aptil 23	April 27	May 1	May 7	May 12	May 15	May 19	May 23	May 26	May 30	June 2	June 5	June 7	June 12	June 15	June 18	June 21	June 24	Total	Average per day
25.	Water	Wheat	0.0	152	169	83	194	122	128	149	258	361	229	244	161	546	700	336	400	300	480	800	500	500	500	850	500	800	800	400	10662	394.9
26.	"	Alfalfa	0.0	74	116	144	167	91	128	125	167	254	163	221	124	522	400	182	300	200	224	500	175	300	300	450	250	400	500	600	6977	258.4
1.	Na_2SO_4	Wheat	2.03	106	125	95	160	160	58	87	184	294	183	248	158	466	533	220	366	383	343	652	454	422	576	627	580	600	700	700	9480	351.1
2.	"	"	3.80	100	165	96	129	105	103	87	178	290	167	200	135	443	519	186	371	336	400	650	430	430	544	644	500	600	700	600	9108	337.3
3.	"	"	7.10	143	152	68	164	126	100	64	142	242	141	158	154	229	467	166	254	215	252	478	434	200	300	400	300	120	400	400	6269	232.2
4.	"	Alfalfa	2.03	100	145	73	128	100	85	86	155	204	143	177	121	300	400	135	240	218	255	600	454	300	480	450	422	500	600	620	7491	277.4
5.	"	"	3.80	138	146	55	127	138	60	100	168	230	140	158	97	330	347	170	243	220	238	664	338	253	420	400	350	420	600	550	7100	262.9
6.	"	"	7.10	*180	100	79	158	127	77	77	162	250	140	174	104	300	388	160	300	200	268	450	238	220	300	441	300	110	400	420	6123	226.8
7.	K_2SO_4	Wheat	2.03	75	196	60	183	148	100	100	266	300	200	266	178	519	605	282	373	300	426	700	378	341	556	540	480	550	600	640	9362	346.7
8.	"	"	3.80	68	227	53	153	140	94	118	189	280	175	191	118	400	478	184	242	200	242	552	359	364	335	445	400	400	550	560	7717	285.8
9.	"	"	7.10	100	166	83	159	100	84	100	145	210	124	172	100	340	400	140	190	200	243	500	200	200	284	316	200	262	300	320	5638	208.8
10.	"	Alfalfa	2.03	43	203	30	180	86	87	92	100	245	168	184	100	270	376	118	244	300	175	551	352	300	436	400	400	500	650	600	7190	266.3
11.	"	"	3.80	60	188	76	151	105	96	102	189	246	178	178	100	300	400	176	226	200	250	500	324	350	245	329	400	400	500	470	6739	249.6
12.	"	"	7.10	110	212	73	138	91	95	100	115	250	191	168	100	300	346	138	225	200	200	400	274	160	300	392	282	300	400	415	5975	221.3
13.	Na Cl.	Wheat	2.03	176	206	98	173	108	123	136	247	293	200	249	186	524	700	252	300	348	456	672	400	400	555	584	500	550	850	680	9966	369.1
14.	"	"	3.80	50	161	74	176	106	100	136	195	290	164	216	146	400	471	200	300	325	348	600	338	248	400	500	400	500	500	600	7944	294.2
15.	"	"	7.10	32	170	78	172	68	100	124	160	234	151	162	102	254	330	200	200	233	340	...	100	142	249	300	200	300	400	320	5221	200.8
16.	"	Alfalfa	2.03	150	190	72	168	96	100	100	182	230	177	172	100	356	400	200	284	252	300	500	353	300	380	500	500	400	700	700	7862	291.2
17.	"	"	3.80	42	160	66	150	104	80	96	150	217	146	195	100	343	340	192	278	236	247	500	300	200	300	370	300	370	420	564	6456	239.1
18.	"	"	7.10	45	168	56	163	84	100	112	126	244	139	200	126	327	376	173	300	200	176	500	200	200	200	300	200	210	300	400	5625	208.3
19.	K Cl.	Wheat	2.03	57	148	123	200	136	123	96	238	284	200	262	100	454	541	268	300	370	288	600	423	400	420	524	500	500	700	533	8788	325.5
20.	"	"	3.80	132	129	137	236	118	153	100	200	300	200	247	138	453	524	236	300	300	300	580	362	323	400	570	310	450	600	530	8328	308.4
21.	"	"	7.10	176	188	136	208	176	148	158	263	200	156	254	119	500	570	292	276	385	392	661	340	349	400	500	350	400	600	600	8797	325.8
22.	"	Alfalfa	2.03	85	147	108	192	98	96	116	212	279	156	196	127	400	356	177	300	188	200	488	391	264	356	500	325	484	600	700	7541	279.3
23.	"	"	3.80	62	159	36	171	71	88	114	183	238	135	198	178	300	420	178	300	141	244	480	286	270	300	400	370	...	600	520	6442	247.8
24.	"	"	7.10	40	182	41	186	76	82	118	144	241	173	179	147	324	400	190	300	171	200	450	200	200	260	235	300	252	250	380	5721	211.9

*48 in excess.

THE DISTRIBUTION OF ALKALI IN THE SOIL OF THE EXPERIMENT FARM.

E. E. SLOSSON.

The most difficult problem of the arid region is to irrigate without bringing out the alkali. In many places, even where the natural negation shows that there is no excess of alkali on the surface, yet there are beds of it several feet below, and when such soil is irrigated it becomes saturated with water and the alkali rises to the surface, where it is left on the evaporation of the water as a white crust. An injurious accumulation of salts on the surface may also occur through improper irrigation in cases where the total amount of soluble salts is not excessive and would be beneficial instead of harmful if properly distributed.

The movement of alkali in the soil under different methods of irrigation has been an especial subject of study on the Laramie experiment farm from the beginning. Analyses of the virgin soil have been made and the amount and composition of all the water used in irrigating is known and a record has been kept of all the crops harvested.

In continuation of this work a number of alkali determinations on different parts of the experiment farm have been made and some of them are here reported in order to put them on record for future reference. The alkali on the Laramie Plains is of the variety known as "White Alkali," consisting mostly of sodium sulphate (glauber salts), with a smalller amount of sodium chloride (common salt).

No uniform method of analyzing soils for soluble salts has been adopted, so there is a great variety of processes and ways of reporting in use and it is often impossible to compare the results of different chemists. The chief difference is in the calcium sulphate or gypsum. In almost all Wyoming soils this is present in abundance, and if the soluble salts are extracted by leaching, a large and variable quantity of calcium sulphate is obtained. If the simpler process of shaking the soil with a known amount of water and taking an aliquot part of the supernatant solution for analysis is adopted the amount of gypsum obtained depends on the quantity of water and soil used. If a complete analysis is to be made the calcium sulphate is determined and can be subtracted, but it is often desirable to run a large number of samples for total alkali alone. In these tests a simple method was used which seems to meet the difficulty. 100g. of soil was put into a glass-stoppered bottle with 200 cc. of distilled water and left for several days with occasional shaking. When it is settled a convenient quantity is drawn off with a pipette and without filtering evaporated to dryness and heated at a temperature above 250°C. for two or three hours. By this heating the gypsum becomes dehydrated and almost insoluble, so all that is necessary is to extract with a small amount of water, filter and evaporate in a platinum dish for total alkali and titrate for chlorides. For dehydration a small round air-bath was made of Russia iron covered with asbestos and containing a rack for holding six smaller porcelain evaporating dishes. A number of experiments made with this method showed that it reduced the amount of soluble salts by about 60 percent, while chlorides remained the same and different amounts of water could be used without affecting the results.

Plats Nos. 19 and 20 were set apart for permanent experiments on the effect of rotation of crops on the composition of the soil. On No. 19 different crops will be grown in rotation and on No. 20 a single crop will be grown continuously for a number of years. The samples were taken June 19, 1896. No. 19 was virgin soil; No. 20 had been in crop one year.

Plats A, B and C were added to the farm June 24, 1899, for permanent irrigation experiments, and the samples were taken then. They were virgin soil and had never been irrigated. Plat A is to be irrigated with the minimum amount of water, Plat B will be given a medium quantity while Plat C will be irrigated frequently and abundantly. The aim of the experiment is to determine the most advantageous duty of water, and as the amount of water used in irrigation has so important an effect on the accumulation of salts in the soil it was thought necessary to determine their distribution at the beginning of the experiment.

There is no general rule to be deduced from these analyses except that the amount of salts gradually increases as we go down. The individual variation in samples is surprisingly large. Sample No. 29, for example, has four times as much alkali as the average of its neighbors. All unusual results were duplicated. Plats A, B and C were supposed to be the same soil, but they contain in the first three feet, respectively, 4531, 1463 and 2886 pounds per acre of alkali salts.

Distribution of Alkali on the Experiment Farm.

Sample No.	Plat No.	Distance from Surface	Total Alkali Per Cent.	Sodium Sulphate Per Cent.	Sodium Chloride Per Cent.	Total Alkali Pounds Per Acre	Sodium Sulphate Pounds Per Acre	Sodium Chloride Pounds Per Acre
11	19	0-3 inches	.053	.050	.003	530	500	30
12		3-6 inches	.064	.056	.008	640	560	80
13		6-9 inches	.089	.078	.011	890	780	110
14		9-12 inches	.067	.061	.006	670	610	60
		1st foot	.068	.061	007	2730	2450	280
15		12-15 inches	.080	.056	.024	800	560	240
16		15-18 inches	.068	.047	.021	680	470	210
17		18-21 inches	.058	.047	.011	580	470	110
18		21-24 inches	.042	.036	.006	420	360	60
		2nd foot	.062	.046	.018	2480	1860	620
19		24-27	.056	.043	.013	560	430	130
20		27-30	.054	.048	.006	540	480	60
21		30-33	.039	.036	.003	390	360	30
22		33-36	.048	.044	.004	480	440	40
		3rd foot	.049	.043	.007	1070	1710	260
		3 feet	.060	.050	.011	6980	6020	1160

Distribution of Alkali on the Experiment Farm.—(Continued).

Sample No.	Plat No.	Distance from Surface	Total Alkali Per Cent.	Sodium Sulphate Per Cent.	Sodium Chloride Per Cent.	Total Alkali Pounds Per Acre	Sodium Sulphate Pounds Per Acre	Sodium Chloride Pounds Per Acre
23	20	0-3 inches	.019	.005	.014	190	50	140
24		3-6 inches	.033	.027	.006	330	270	60
25		6-9 inches	.036	.032	.004	360	320	40
26		9-12 inches	.020	.016	.004	200	160	40
		1st foot	.027	.020	.007	1080	800	280
27		12-15 inches	.024	.020	.004	240	200	40
28		15-18 inches	.016	.014	.002	160	140	20
29		18-21 inches	.071	.070	.001	710	700	10
30		21-24 inches	.020	.017	.003	200	170	30
		2nd foot	.033	.030	.002	1310	1210	100
		2 feet	.030	.025	.004	2390	2010	380
120	A	0-4 inches	.033	.027	.006	440	360	80
121		4-8 inches	.027	.021	.006	360	280	80
122		8-12 inches	.033	.024	.009	440	320	120
		1st foot	.031	.024	.007	1240	960	280
123		12-15 inches	.031	.023	.008	413	306	106
124		16-20 inches	.029	.023	.006	386	306	80
125		20-24 inches	.036	.024	.012	480	320	160
		2nd foot	.032	.023	.008	1279	932	346
126		24-28 inches	.038	.019	.019	506	253	253
127		28-32 inches	.045	.020	.025	600	267	333
128		32-36 inches	.068	.036	.032	906	480	426
		3rd foot	.050	.025	.025	2012	1000	1012
		3 feet	.038	.024	.013	4531	2892	1638
129	B	0-4 inches	.018	.014	.002	240	214	26
130		4-8 inches	.011	.008	.003	146	106	40
131		8-12 inches	.008	.005	.003	106	66	40
		1st foot	.012	.009	.003	492	386	106
132		12-16	.011	.005	.006	146	66	80
133		16-20	.009	.003	.006	120	40	80
134		20-24	007	.004	.003	93	53	40
		2nd foot	.009	.004	.005	359	159	200
135		24-28	.008	.005	.003	106	66	40
136		28-32	.009	.006	.003	120	80	40
137		32-36	.023	.020	.003	386	346	40
		3rd foot	.013	.010	.003	612	492	120
		3 feet	.011	.080	.004	1463	1037	426
138	C	0-4 inches	.012	.009	.003	160	120	40
139		4-8 inches	.011	.007	.004	146	96	50
140		8 12 inches	.018	.014	.004	240	190	50
		1st foot	.014	.010	.004	546	406	140
141		12-16 inches	.016	.013	.003	210	170	40
142		16-20 inches	.030	.026	.004	400	350	50
143		20-24 inches	.024	.020	.004	320	270	50
		2nd foot	.023	.020	.004	930	790	140
144		24 28 inches	.028	.024	.004	360	310	50
145		28 32 inches	.034	.024	.010	450	317	133
146		32-36 inches	.045	.032	.013	600	427	173
		3rd foot	.036	.027	.009	1410	1054	356
		3 feet	.024	.019	.006	2886	2240	646

WATER MEASUREMENTS

By B. C. BUFFUM.

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LARAMIE, WYOMING.

Water Measurements.*

BY B. C. BUFFUM.

The water measurements made by the Station in 1891 and 1892 were reported in Bulletin No. 8. As this bulletin is out of print, the table of duties there reported is given below. Since 1892 measurements of the water used on the Station farm at Laramie have been made each year, and a series of measurements were made at Wheatland in 1893. The measurements at Laramie in 1893 were of no value, as all crops failed that season, and in 1894 the record was incomplete and not sufficiently accurate for publication. Since 1894, however, a large number of determinations of duty have been made. With the exception of some measurements in 1899 made in coöperation with Professor Elwood Mead of the Office of Experiment Stations, the duties so far determined are reported in the following tables:

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*All the measurements of water up to the close of the season of 1898 have been reported in Bulletin No. 81 of the Office of Experiment Stations of the U. S. Department of Agriculture, entitled "The Use of Water in Irrigation in Wyoming and its Relation to the Ownership and Distribution of the Natural Supply." The tables on duty given in this paper are the same as those used in that bulletin with the addition of report on the first year's measurement to show amount of water necessary to produce a maximum crop in 1899 and amount of water used in a sub-irrigation system at Laramie, along with the measurements for 1899 by the Station. The co-operative measurements for 1899 have been reported to Professor Mead of the Office of Experiment Stations.

TABLE I.—*Duty of water, Wyoming Experiment Station, 1891-92.*

Place.	Crops.	Yield per acre.	Rainfall for four months.*	Date irrigated.	Total amount of water used.	Average depth of irrigation water on land.	Duty of 1 cubic foot per second continuous flow.*
1891.			*Inches.*		*cu. ft.*	*Inches.*	*Acres.*
Laramie	Mixed	. . . .	6.16	. . . .	2,667,288.75	30.6	95.62
Wheatland	Oats	40 bushels	3.50	June 20 to July 12.	9,507,073.47	17.4	167.69
1892.							
Laramie	Sugar Beets Rutabagas	8.6 tons. 18 tons.	†6.99	June 16, 17 Aug. 16 Sept. 22	97,973.24	9.9	299.77
Do	Corn	Cut for fodder.	†6.99	July 20	10,848.39	4	736.29
Do	Cane, durra	. . . .	†6.99	July 23	19,754.92	8.7	336.02
Do	Peas, beans	7 bushels.	†6.99	June 5	18,081.13	4.9	588.23
Do	Mixed	. . . .	†6.99	. . . .	1,180,511.41	13.5	216.06

*Four months of growing season—May, June, July and August.

†5.13 inches fell in May and June.

TABLE II.—*Duty of Water on Alfalfa, 1891-1899.*

No.	Year.	Area.	Date Planted	No. of Irrigations	Water received by Irrigation per Acre.		Depth of Water Supplied by Irrigation and Rainfall in year	Depth of Water received by Irrigation and Rainfall in growing season*	Duty of 1 sec. ft. for season of 4 months.	Duty of 1 sec. ft. for season of 95 days.	Yield per Acre	Remarks.
					Quantity	Depth over Surface						
		acres.			*cu. ft.*	*ft.*	*ft.*	*ft.*	*acres*	*acres*	*lbs.*	
1	1893	1.	1891	6	113,184	2.60	3.13	2.71	93.8	72.6	15752	At Wheatland. Three crops.
2	1896	.52	1894	2	47.356	1.08	1.98	1.69	224.5	173.3	4664	Laramie. Two crops.
3	1898	1.	1898	4	129,388	2.97	3.61	3.35	82.0	63.4	2220	Laramie. First year.
4	1898	3.9	1894	5	113,101	2.60	3.24	2.98	94.0	72.6	8668	Laramie. Two crops.
5	1899	3.87	1897-98	4	135,365	3.11	4.02	3.53	78.5	60.7	5319	Laramie.
6	1899	.95	1897	3	84,663	2.14	3.05	2.56	125.5	97.0	5510	Laramie. Average yield with and without nurse crop.
7	1899	.50	1897	3	103,680	2.38	3.20	2.80	102.5	79.2	6206	Laramie. Sown with oats in '97, two crops.
8	1899	.70	1899	2	100,190	2.30	3.21	2.72	106.1	82.1	1187	Laramie. First year.
9	1899	.95	1897	1	42,689	0.98	1.89	1.40	249.0	192.3	3188	Laramie. One-half of plat killed by alkali.
10	1899	.03	1895	3	78,219	1.82	2.73	2.24	135.9	104.9	7862	Laramie. Turkestan Alfalfa.
11	1899	.98	....	3	103,900	2.38	3.29	2.80	102.3	79.0	...	Laramie. With Oats.
12	1899	.25	1899	3	104,226	2.39	3.30	2.81	102.0	78.8	...	Laramie. First year, with Oats.
13	1899	.96	....	2	70,132	1.61	2.52	2.03	151.6	117.0	...	Laramie. With Oats.
14	1899	.46	1899	3	134,165	3.08	3.99	3.50	79.2	61.2	1766	Laramie. First year, with Timothy.
15	1899	5.4	1899	2	98,881	2.27	3.18	2.69	107.5	83.0	...	Laramie. First year, on sod with Oats.

*Growing season five months—May, June, July, August and September.

TABLE III.—*Duty of water, other hay crops than alfalfa, 1893-1898.*

Crop.	Place.	Year.	Water received by Irrigation per acre.		Depth of water supplied land by Irrigation and Rainfall.		Duty of 1 second-foot for season.		Yield per acre.
			Quantity	Depth over surface.	Growing season	Year.	Four months	Ninety-five days	
			cu. ft.	*ft.*	*ft.*	*ft.*	*acres.*	*acres.*	*lbs.*
Brome grass, first year.	Laramie	1898	129,811	2.98	3.36	3.62	81.9	63.2	. . . .
Native hay	do.	1898	174,240	4	4.38	4.64	61	47.1	. . . .
Oats and vetch	do.	1898	68,753	1.58	1.96	2.22	151.7	119.4	5.563
Timothy	Wheatland	1893	102,384	2.35	2.50	2.88	103.8	80.2	2.212

TABLE IV.—*Duty of water, grain crops, 1893-1898.*

Crop.	Place.	Year.	Water received by irrigation per acre.		Depth of water supplied land by irrigation and rainfall.		Duty of 1 second-foot for season.		Yield per acre.
			Quantity.	Depth over surface.	Growing season.	Year.	Four months.	Ninety-five days	
			cu. ft.	*ft.*	*ft.*	*ft.*	*acres.*	*acres.*	*lbs.*
Barley:									
Three varieties.	Wheatland	1893	39.744	0.91	1.06	1.44	267.4	206.5	864
Nine varieties.	Laramie	1895	52,895	1.21	1.88	2.14	200.9	155.1	896
Highland Chief.	do.	1898	117,711	2.70	3.08	3.34	90.3	69.7	1392
Corn, Minnesota King.	Wheatland	1893	47,520	1.09	1.24	1.62	223.6	172.7	3189
Oats:									
Giant Side	do.	1893	76,896	1.77	1.92	2.30	138.2	106.7	1603
Early Archangel.	do.	1893	68,256	1.57	1.72	2.10	155.7	120.3	1024
Lincoln Surprise Bonanza	Laramie	1898	82,647	1.90	2.28	2.54	128.6	99.2	*1688
Lincoln (on sod).	do.	1898	112,579	2.58	2.96	3.22	94.4	72.9	698
Surprise (subsoiled).	do.	1898	160,835	3.69	4.07	4.33	66.1	51	1634
Rye:									
Spring	Wheatland	1893	56,160	1.29	1.44	1.82	189.2	146.2	974
Winter	do.	1893	38,448	.88	1.03	1.41	276.4	213.5	739
Spring	Laramie	1898	58.123	1.33	1.71	1.97	182.8	141.2	556
Wheat:									
White Russian.	Wheatland	1893	69,084	1.61	1.76	2.14	151.9	117.3	1962
Fultz Winter.	do.	1893	41,040	.94	1.09	1.47	258.9	200	486
Five varieties.	Laramie	1898	158,001	3.63	4.01	4.27	67.3	51.9	†1573

*Average yield of the three varieties. †Average yield of five varieties.

TABLE V—*Duty of water, mixed crops—Grains, peas, and flax, 1893-1898.*

CROP.	Place.	Year.	Water received by irrigation per acre.		Depth of water supplied by irrigation and rainfall.		Duty of 1 second-foot for season.	
			Quantity.	Depth over surface.	Growing season.	Year	Four months.	Ninety-five days.
			Cubic Feet.	*Feet.*	*Feet.*	*Feet.*	*Acres.*	*Acres.*
Grains, root crops, hay and garden	Laramie	1895	50.266	1.15	1.82	2 08	211.4	163.3
Wheat, 18 varieties; oats, 3 varieties	do	1896	52,895	1.21	1.61	2.11	200.9	155.2
Barley, oats and wheat	do	1896	63,296	1.45	1.85	2.35	167.9	129.7
Garden (furrow irrigated)	do	1896	54.270	1.25	1.65	2.15	195.8	151.2
Grain (wheat, oats, barley, furrow irrigated)	do	1896	61,122	1.40	1.80	2.30	173.9	134.3
Wheat and oats (sod land)	do	1896	41,886	.96	1.36	1.86	253.7	196
Wheat (Blount No 16), oats (Lincoln)	do	1897	107.012	2.46	2.87	3.46	99.3	76.7
Oats, rye, barley, and flax	do	1897	69,345	1.59	2	2.59	153.4	118.4
Grain (varieties furrow irrigated)	do	1897	66,467	1.53	1 94	2.53	159.9	123.5
Oats (Surprise and grains furrow irrigated)	do	1898	67.477	1.55	1.93	2.19	157.5	121 6
Wheat (Blount No. 16), oats (Lincoln)	do	1898	75,853	1.74	2.12	2.38	140.1	108.2
Peas	do	1897	74,699	1.71	2.12	2.71	142.3	109.9
do	do	1897	136,408	3.13	3.54	4.13	78	60.2
do	do	1898	124,304	2.85	3.23	3 49	85.5	66
Barley (Highland Chief), wheat (Scotch of Scotch)	do	1898	75,159	1.73	2.11	2.87	141.4	100.1
Oats, rye, barley, and flax	do	1897	69,345	1.59	2	2.59	153 3	118.4
Flax, 2 varieties	Wheatland	1893	95,040	2.18	2.33	2.71	111.8	86.4

TABLE VI—*Duty of water, root crops, 1893-1898.*

CROP.	Place.	Year.	Water received by irrigation per acre.		Depth of water supplied land by irrigation and rainfall.		Duty of 1 second-foot for season.		Yield per acre.
			Quantity.	Depth over surface.	Growing season.	Year.	Four months.	Ninety-five days.	
			Cubic feet.	*Feet.*	*Feet.*	*Feet.*	*Acres.*	*Acres.*	*Pounds.*
Potatoes	Laramie	1895	11,683	0.27	0.95	1.20	909.6	702.6	9,000
Do	do.	1896	13,866	.32	.72	1.22	766.5	592	.....
Do	do.	1897	26,237	.60	1.01	1.60	405	312.8	.....
Potatoes, 3 irrigations	do.	1898	49,825	1.14	1.54	1.78	213.3	164.7	8,675
Potatoes, 2 irrigations	do.	1898	12.925	.30	.68	1.94	822.2	635	5.131
Potatoes, 22 varieties	Wheatland	1893	61,776	1.42	1.57	1.95	172	132.9	7,344
Sugar beets and ruta-bagas	Laramie	1898	69.875	1.60	1.98	2.24	152.1	117.8	.....
Sugar beets, 4 varieties	Wheatland	1893	107,128	2.46	2.61	2.99	99.2	76.6	12,912
Turnips aud ruta-bagas	Laramie	1895	112,733	2.59	3.27	3.52	94.3	72.8	.....

TABLE VII—*Duty of water for various crops, 1899, Laramie.*

No.	CROP.	Plat.	Area	No. of irrigations.	Water received by irrigation.		Depth of water received by irrigation and rainfall in growing season.	Duty of 1 second-foot for season of 4 months, 123 da.	Duty of 1 second-foot for 95 days.	Yield per acre.	Remarks.
					Quantity	Depth over surface					
			acres		*cubic ft.*	*ft.*	**ft.*	*acres*	*acres*	*pounds*	
1	Amethyst wheat . .		0.88	1	24,358	0.64	1.06	383.7	295.87	911	Cut green for hay.
2	Garden.		1.5		148,603	2.27	2.69	107.3	82.85	. . .	Root crops, pease, lettuce, cabbage, etc.
3	Artichokes	4	0.27		7,685	.65	1.07	297.5	289.1	5300	Estimated from yield of one row.
4	Brome grass	9	0.41	3	46,190	2.60	3.02	93.9	72.5	593	Second year from sowing the seed.
5	Sand vetch	9	0.57	1	10,954	.44	.86	549.5	424.3	1174	
6	Grasses	16	0.95	3	75,430	1.82	2.24	106.3	103.4	. . .	Varieties in small plats.
7	Potatoes		0.99	1	46,030	1.07	1.49	228.5	176.5	3062	Yield is of marketable tubers.
8	Potatoes	3	0.68	1	18,065	.61	1.03	401.4	310.	3445	Yield is of marketable tubers.
9	Potatoes	8	0.30	1	10,080	.77	1.19	177.2	136.8	3616	Yield is of marketable tubers.
10	Grain	21	0.98	2	61,735	1.45	1.87	172.3	113.9	864	Yield given is of barley; yield of wheat is 939 lbs., and of rye 449 lbs.
11	Bonanza oats. . . .	19	0.96	2	66,868	1.59	2.01	153.3	118.4	1436	
12	Oats and wheat. . .	8	0.65	2	40,896	1.43	1.85	170.	131.3	1738	Yield given is of oats; yield of wheat is 1.444 lbs.
13	Mixed crops, grain, pease, millet . . .		2.39	2	164,929	1.57	1 99	155.2	119.87	. . .	
14	Wheat and oats. . .	20	0.97	2	58,045	1.38	1.80	176.7	136.5	836	Yield is of oats; wheat yielded 516 lbs.
15	Pease	22	0.98	2	69,490	1.63	2.05	149.8	115.7	5070	Cut green for hay.
16	Wheat	3	0.25	2	14,220	1.31	1.73	186.8	144.3	1037	
17	Dwarf Essex Rape .	1	0.11	1	11.773	2.39	2.81	101.9	78.8	31920	Yield given is the weight of green crop.
18	Oats		0.25	1	8,098	.75	1.17	324.8	250.8	802	Small plat on alkali ground.
19	Potatoes		0.34	2	12,726	.85	1.22	286.0	220.9	. . .	

*Rainfall for growing season of May, June, July, August and September is 0.42 feet.

SUB-IRRIGATION.

Two systems of sub-irrigation have been under observation for a number of years. One of these consists of an iron pipe two inches in diameter and 900 feet long, used on the campus for irrigating trees.* This pipe has given very satisfactory results, but it has not been practicable to measure the amount of water used in it. The other system consists of one-half acre on the Experiment Farm which is underlaid with porous tile. Lines of four-inch tile are placed eighteen inches deep and at distances of twenty feet apart. These lines of pipe join six-inch mains extending around the plat, which serve as feed and drain pipes. The system was established in the spring of 1895 and that season the land was planted to varieties of small fruits. These failed to grow and since 1895 the plat has produced other crops in rotation—turnips, oats, potatoes, and wheat. Previous to last season the measuring of water used in sub-irrigating this plat was neglected. Last season a series of careful measurements were made to show how much water was used. It should be stated that the soil is a sandy loam,mixed with gypsum, which gives it a sticky, clay-like consistency, with gypsum and lime subsoil at about the depth the tile is laid. Water does not pass through this soil readily and the pipes are too far apart, so the crop midway between the lines of pipe does not receive enough water. This is very apparent when grain is grown on the plat, as it makes tall, thrifty growth over the pipes and short growth between. giving the plant a wave-like aspect, like the surface of a washboard or the smooth swells of an unruffled sea. Last season the plat was planted to wheat, which was irrigated by letting water run into the pipes at night, keeping careful records of the time and depth with a water register. A very small head was used, the water flowing over an eighteen-inch weir with an average depth of a little more than one-half inch. The measurement, as reported below, is approximately correct. The area of the plat was 0.465 acre.

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*For description see Wyo. Sta. Bul. No. 8, p. 23.

TABLE VIII—*Duty of Water.—Wheat Sub-irrigated, 1899.*

Water received by sub-irrigation.		Depth by Irrigation and Rainfall, growing season.	Duty of 1 second foot for season.		Yield per acre.	
Quantity.	Depth on surface.		Four months	Ninety-five days.	Straw and Grain	Yield, Grain.
cubic ft. 62546	*ft.* 3.091	*ft.* 3.51	*acres.* 79.1	*acres.* 61.2	*lbs.* 3873	*lbs.* 962*

*Blackbirds took much of the grain before it was threshed.

Irrigation began June 29 and ended August 2nd. We have long known that the value of land in Wyoming is not yet sufficiently great to merit the first expense of establishing such systems of sub-irrigation. Our results with this plat do not indicate that extraordinary crops are produced by this method of applying water, or that it is economical from the standpoint of the amount of water required to produce a crop. More water was used on the sub-irrigated land last season than on any other plat on the farm except one small field of alfalfa.

AMOUNT OF WATER NECESSARY TO PRODUCE A MAXIMUM CROP.

All our determinations of duty have been compared with crop production, but no experiments were carried out to determine the amount of water most favorable to crops, or the amount necessary to produce a maximum yield until last year. About eleven acres of the new land which was planted to oats was divided into three plats, marked A, B, and C. The plan was to give plat C what would ordinarily be called an excessive amount of water, give B medium irrigation, and supply A with as little water as would mature the crop. Table IX gives the data computed from last season's notes.

TABLE IX—*Amount of Water to Produce Maximum Crop.—Oats, 1899.*

Plat.	Area in acres.	Date planted.	No. of irrigation	Date irrigated.	Water received by irrigation.			Depth of water supplied land by irrigation and rainfall, growing season.	Date harvested.	Height of grain when ripe.	Average length of heads.	Yield per acre.	
					Quantity.	Depth over surface	Total depth					Straw and Grain.	Grain.
					cubic ft.	*ft.*	*ft.*	*ft.*		*ft.*	*ft*		
A	2.78	April 24-26	1	June 30 July 1	78376	0.65							
			2	July 25-26	23778	0.19	0.845	1.265	*Sept. 4	2.1	0.45	1071	491
B	4.94	do	1	June 27-30	201893	0.94							
			2	July 17-18	95586	0.44	1.38	1.80	Sept. 3-4	2.3	0.45	1229	446
C	4.41	do	1	June24-26	160828	0.84							
			2	July 12-17	118549	0.62							
			3	July 22	72195	0.35							
			4	Aug. 2	59496	0.31	2.14	2.56	Sept. 3	2.5	0.55	1489	567

*Plat A ripened a little later than the other plats, though there was but little difference in time of ripening.

The results do not indicate that even the largest amount of water applied was sufficient to produce a maximum crop. Sod land requires more water than is necessary on older cultivated soil, and the largest amount or water applied was not excessive. The time of applying water is of great importance. Irrigating at the wrong time may account for the decrease in yield of grain in Plat B, while the amount of straw was increased by the additional water it received.

Samples of soil were taken from each plat twice each week during the summer for determinations of the amount cf moisture in the soil. A part of the determinations were made by Mr. Danielson and a part by Mr. Moudy in the Chemical Department. The soil samples were taken by driving iron tubes into the ground a distance of one foot. They were corked up with rubber corks at each end until they could be dried. The samples obtained in this way were not uniform. Sometimes the tube would drive into the soil, filling nearly its whole length, and at other times the soil would apparently drive down ahead of the lower end, so that not more than one or two inches of soil would be obtained. This throws doubt on the uniformity of the samples taken and makes the moisture determinations of little or no scientific value. However, there were fifteen determinations from each plat, and the averages show small differences in the percent of moisture from each. With this explanation, the moisture determinations are published in Table X. Plat A, which had the least irrigation, apparently had the largest average moisture content, though the variation is small and may be accounted for by the way the samples were taken.

TABLE X—*Soil Moisture in Plats A, B, and C, 1899.*

Plat.	July 11.	July 14.	July 17.	July 20.	July 24.	July 28.	July 31.	August 3.	August 6.	August 12.	August 15.	August 18.	August 22.	August 25.	August 28.	Average.
A. .	3.38	6.89	8.78	9.56	8.41	16.48	15.30	13.05	16.66	12.99	9.55	11.17	7·96	7.27	8.19	10.38
B . .	3.85	8.81	17.49	11.59	8.59	8.48	9.13	6.32	12.00	5.11	4.29	6.40	4.44	5.35	3.34	7.68
C . .	3.93	9.88	16.06	12.00	11.35	11.96	12.00	13.19	11.58	9.46	5.38	6.55	3.62	3.85	3.88	8.98

In 1898 an experiment to show the effect of different amounts of water on potatoes was carried out.*

"A part of the potato field was given the first irrigation July 7, while a part was left until July 28 for the first watering, at which time the potatoes irrigated on July 7 were given their second irrigation, and all were irrigated again on August 4. The potatoes were planted in rows running across two plats, one of which was plowed in the ordinary way. The other plat was treated the same, but had been subsoiled in the spring of 1896 to a depth of 16 or 18 inches. The potatoes irrigated twice received 3.6 inches of water, while those irrigated three times received 13.8 inches. The yields of marketable potatoes per acre are given in the following table:

TABLE XI—*Yield of Potatoes with Two and Three Irrigations.*

Irrigations.	Land plowed	Land plowed and sub-soiled.	Average yield.
	Pounds.	*Pounds.*	*Pounds.*
Irrigated twice	4,972	5,290	5,131
Irrigated three times	8,759	8 591	8,675
Increase.	3,787	3,301	3,544

"This table shows an increased yield due to the additional irrigation of over 76 percent on land treated in the usual way, and of nearly 62.4 percent on subsoiled land, the average increase being over 69 percent."

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*Bulletin No. 81, Office of Experiment Stations, U. S. Department of Agriculture.

Some studies made by the writer on the amount of water on amount of crop, which were published in Bulletin No. 81 of the Office of Experiment Stations, "The Use of Water in Irrigation in Wyoming," were summarized as follows:

* * * There is a limit to the volume of water which can be used to advantage, beyond which it is an injury to both land and crop. With alfalfa the largest yield was obtained with the least water per pound produced, and the same is true in several cases with the grains and potatoes. However, * * * the results indicate that in general the greatest depth of water applied to the crop by irrigation nearly corresponds to the maximum yield, except in the case of grains on sod land, or potatoes, which received little irrigation.

"It will thus be seen that we are unacquainted as yet with the amount of water necessary to produce the best results under any known conditions. With too little water. failure of the crop is certain, and too much water is often injurious. So far, we have been able to obtain only a general idea of the amount of water necessary to carry on successful agricultural operations and produce crops which give larger average yields than those raised under rainfall. Undoubtedly, applying water to the plant when it needs water and not forcing it to exist in the presence of water in excess of that required is the only scientific way of producing crops."

GERMINATION OF WHEAT AND OATS TREATED FOR SMUT.

PUBLISHED AS PART OF THE TENTH ANNUAL REPORT OF THE
WYOMING AGRICULTURAL EXPERIMENT
STATION.

The loose smut of oats and the stinking smut of wheat are very troublesome on the Laramie Plains. Unless the seed planted be absolutely free from the smut spores it is impossible to raise clean grain, and if untreated seed is planted, even though it appears to contain very little smut, the loss to the resulting crop is great. In one instance, actual count of kernels after threshing gave 80 smut kernels to 42 sound ones, or over 190 percent smut, and many of the diseased kernels were broken to pieces in the threshing. Several different methods of treating grain for smut were resorted to the present season and after treatment as nearly average samples of the grain as could be selected were placed in the germinating chamber to determine the effect of the treatment on vitality of the seed. Several samples of untreated seed were germinated as checks. The observations were made April 16 to 27, 1900. The methods of treatment were as follows:

COPPER SULPHATE OR BLUE STONE TREATMENT:—A solution was made by dissolving one pound of commercial copper sulphate in twenty-four gallons of water. Amethyst wheat and Lamona wheat were soaked in this solution for ten and one-half hours. Scotch of Scotch wheat was soaked for thirteen hours. Upon removing the wheat from the sulphate solution it was immersed for five minutes in a solution made by slacking one pound of good lime and then diluting to ten gallons with water.

POTASSIUM SULPHIDE TREATMENT.—A two per cent solution was made by dissolving eight pounds of potassium sulphide in fifty gallons of water. Surprise and Lincoln oats were soaked in this solution for two hours and then spread out to dry.

THE JENSEN HOT WATER TREATMENT:—Two barrels of water were heated by passing steam into them. A reliable thermometer was used to test the temperature. The water in barrel No. 1 was heated to about 130°F. The grain in sacks was placed in this water, which would lower the temperature ten or fifteen degrees when immersed. The water in barrel No. 2 was heated to from 130 to 135°F. The grain was lifted from barrel No. 1 to barrel No. 2 and left in the water heated to 130 or 135°F. for ten minutes. If the temperature decreased to less than 130°, the grain was lifted out and steam passed in to increase the heat to the proper degree, when the grain was replaced until the actual time it was immersed amounted to a total of ten minutes. In some instances when the water was at a lower temperature than 130°F., the grain was left in longer than the ten minutes specified for the proper temperature, i. e.. the time the grain was in the water was not counted unless the temperature was at or above a minimum of 130°F. Scotch of Scotch wheat, Surprise oats and Lincoln oats were treated in this manner. Great care was taken not to have the water too hot or leave the grain in too long, but the result on the germination of the seed shows that too much heat was applied. All the grain treated, except the Lamona wheat, was raised at Laramie in 1899. It is possible that grain raised at this altitude, on account of its rapidity of growth and the short season, does not produce seed coats which are so thick as that of grain raised where the season is long, and that the thin seed coats account for the destruction of germinating power by water at a temperature supposed to be safe in other places, or by the salt solutions commonly used elsewhere. The following table gives the results of the germinating test of the treated grains compared with check samples not treated:

Germination of Wheat and Oats Treated for Smut.

No.	Grain.	Treatment.	Percent germinated each day from time of planting.								Total per cent germinated.	Seed from
			1	2	3	4	5	7	9	11		
1	Wheat, Lamona. . . .	None	16	97	99	100	..	..	..	..	100	U. S. Dept.
2	" "	Copper Sulphate. .	7	49	77	89	91	93	97	..	97	U. S. Dept.
3	" Amethyst.	. . . . do	1	13	46	64	71	76	80	81	81	Laramie.
4	" Scotch of Scotch	None	..	74	88	96	..	97	..	..	97	do
5	" "	Copper Sulphate. .	13	68	74	79	82	84	85	..	85	do
6	" "	Hot Water.	..	..	..	1	3	6	..	..	6	do
7	" Chili	Corrosive Sublimate	..	62	78	86	88	92	..	93	98	do
8	Oats, Surprise	None.	..	..	27	51	68	81	82	..	82	do
9	" "	Potassium Sulphide.	..	..	30	46	..	52	54	57	57	do
10	" "	Hot Water.	..	..	9	13	16	20	23	28	28	do
11	" Lincoln	None.	..	..	34	81	94	97	98	..	98	do
12	" "	Potassium Sulphide	..	..	30	46	53	55	56	57	57	do
13	" "	Hot Water.	..	..	6	14	23	26	..	28	28	do

FORAGE PLANTS

By B. O. BUFFUM and W. H. FAIRFIELD.

PUBLISHED AS PART OF THE TENTH ANNUAL REPORT OF THE WYOMING EXPERIMENT STATION.

JULY, 1900.

LARAMIE, WYOMING.

Forage Plants.

BY B. C. BUFFUM AND W. H. FAIRFIELD.

It is the object of this paper to report briefly and more or less technically the investigations by the Experiment Station with cultivated and native forage plants for the Laramie Plains. The Station early took up work with forage plants and Bulletin No. 16 was the first report on them. This bulletin gave accounts principally of the native forage plants which had been collected up to that time. Brief reports have been made from time to time by this and other departments, more especially with forage plants for alkali soils.*

No subject which is being investigated promises results of so great value to the farmers of the State. Where live stock is the basis of agricultural practice, as it is and must be in Wyoming, the importance of raising abundant and cheap stock food can hardly be overestimated. The natural ranges have greatly deteriorated through over-stocking, which has prevented the best grasses from re-seeding themselves for so long a time that they have run out. Not only is the improvement of the native range important, but greater hay production from our native and cultivated meadows is a matter of prime importance. No doubt there are many grasses and forage plants which can be introduced and cultivated that will greatly increase the yield of hay obtained. This matter is of such vital interest that our farmers and ranchmen are ever ready to spend their money for greatly advertised grasses or forage plants, and go to much trouble and expense giving them trial on their hay lands. Many bought sachaline, which proved absolutely valueless in every part of the state. Many more are buying Australian salt bush, which is a tropical plant and will not succeed in our climate. Ranchmen everywhere are now buying seed of the Awnless Brome grass, which our experiments have shown is poorly adapted to our ***high*** altitudes. It seems that a ton of it will cost more than it will ever be worth, as it makes slow growth and produces very small yields at Laramie. However, it is a valuable grass in some localities, especially where the rainfall reaches 17 to 20 inches per annum.

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*See Wyo. Sta. Bul. No. 42, by Aven Nelson, Botanist of the Station.

We have tried many varieties of grasses and many kinds of other forage plants. In 1895 we began co-operation with the Division of Agrostology of the United States Department of Agriculture, from which source we obtained many varieties of seed which are not obtainable as yet except in very small amounts as collected in the native home of each plant. These have been grown with the hope that some among them might prove worthy of extended planting and spreading of the seed among our farmers. Results of value have been obtained. Some of the kinds tried have already been proven worthless, others have not yet been sufficiently investigated to enable us to form an opinion of their value, and still others have given most promising results. We believe the following brief report of these trials will be of interest and value.

At the end of this report we have given three lists of forage plants, the first one being a list of those which have shown themselves worthy of further trial, the second one being a list of those which have not yet furnished sufficient data from which to determine their usefulness or uselessness, and the third one being a list of those which have proven themselves useless under the conditions of climate at our high altitude. The second list, no doubt, contains many plants which are valueless at this altitude, but unless our results have been such as to fully prove them so, we have given them the benefit of the doubt.

ALFALFA *(Medicago sativa.)*

Results obtained by the Station in cropping alfalfa are reported in Bulletin No. 43, and need not be repeated here. Its value as a fertilizer was reported in Bulletin 44. No other forage plant which has been tried approaches alfalfa in general value. It ranks first in Wyoming. It is productive and adapts itself to our conditions of soil and climate. Alfalfa must be irrigated and cannot be grown on low wet land. At altitudes over 6,000 feet it should be given special preparation of the land and be planted with a press drill.

ALSYKE *(Trifolium hybridum.)*

A plat planted in 1896 made a poor stand. The plants grew well in the summer of 1897 but winter killed the following winter. Plants have spread to different parts of the farm and grow well along the ditches, or where covered with snow drifts in the winter. It may have some value to improve wet meadows, especially in sheltered places.

RED CLOVER *(Trifolium pratense.)*

A plat planted with press drill May 1st, 1894, made poor stand. Harvested August 9, 1895, and yielded 1,426 pounds per acre. Another plat planted May 23, 1896, made a scattering stand. It was cut to clean off weeds in 1897. In 1898 the plat yielded 2,628 pounds per acre. In 1899 it yielded 1,080 pounds per acre and 1,800 pounds per acre in 1900. Red clover is apt to winter kill at this altitude and cannot be expected to produce a crop the first season from seed.

Mammoth red clover was planted in 1896. In 1897 it was growing, but a poor stand was secured, and practically all was winter killed in following winter.

CRIMSON CLOVER *(Trifolium incarnatum.)*

Has been tried at Laramie but failed.

WHITE CLOVER *(Trifolium repens.)*

Is used in lawns. Grows well and spreads rapidly where kept wet. Is apt to winter kill.

EGYPTIAN CLOVER *(Trifolium Alexandrinum.)*

Planted May 22, 1896. Good stand. Blossomed August 5. Grew six to eight inches high. Was not cut.

BOKHARA CLOVER *(Mililotus alba.)*

Planted on May 21, 1896, on alkali ground. Produced only a medium stand. Cut in 1897 but no record of yield was kept.

Planted May 12, 1897, on alkali land with press drill. August 1, 1898, plants in full bloom. Highest plants, 6½ feet. Yield cured hay, 9,226 pounds per acre. In 1891 some seed was planted on high land which could not be irrigated It grew 9 inches high the first season and ripened seed the second year, re-seeding for several years. This clover is a great drouth and alkali resisting plant. It has a strong odor and is unpalatable to stock. In the presence of superior forage it is hardly worth while to attempt to educate stock to eat it. Its only value in our state is as a honey plant (for which purpose it is superior to almost any other), and as a plant to grow on strong alkali ground for green manure. See Wyo. Sta. Bul. No. 16, p. 236.

BURR OR CALIFORNIA CLOVER *(Medicago maculata.)*

Planted in 1895. Grew well and re-seeded every year for four years. This is a small annual recumbent clover which would only be of value for pasturage, where the seed could be harrowed in each year.

FLAT PEA *(Lathyrus sylvester wagneri.)*

The seed was planted and the roots were also set out in the spring of 1895. It makes a luxuriant growth, resists drouth well and does not winter kill. We cut it but once during the season. Its serious and, in Wyoming, fatal drawback, like the sweet clover, is lack of palatability. We have not been able to induce stock to touch it, either green or cured for hay. It requires three or four years for it to become well enough established to produce heavy yields at Laramie.

ENGLISH OR DWARF ESSEX RAPE *(Brassica napus.)*

In 1894 rape planted on alkali soil yielded 14.59 tons green forage per acre. In 1899 it yielded 15.95 tons green forage per acre. It is relished by stock and will be eaten through the winter as long as any of it is left standing. After being frosted, if eaten by milch cows it is apt to give an unpleasant flavor to the milk and butter. It is necessary to plant rape each year, but it promises to be of great value, especially for alkali land.

BROME GRASS *(Bromis inermus.)*

The first plat was planted in the spring of 1896. Since then two or three more plats have been planted. We have given it a very thorough trial and find that it is easy to start, resists drouth and our severe winters, but will produce scarcely enough hay to pay for cutting. One plat of nearly one-half acre yielded at the rate of 593 pounds cured hay per acre in 1899. and this is representative of what it has done during the four years we have tried it on the Station Farm at Laramie. It might be well to state, however, that at lower altitudes in the state, particularly in the vicinity of Sundance, it had proved itself to be of much value as a hay crop.

SANFOIN OR ESPARSETTE *(Onobrychis sativa.)*

This was planted with a press drill on native prairie in 1892. It was irrigated the first season. It made some growth, resisted drouth well, and did not winter kill. It may prove of value to improve the range, but no experiments in this particular line have yet been carried out. In 1896 a plat was planted and made a scattering stand. It made a good growth in 1897 but the yield was not taken. In 1898 it yielded at the rate of 4,666 pounds cured hay per acre, and in 1899, 2,736 pounds. On the whole it seems to be a very promising forage plant for this region, but does not yield so much hay as does alfalfa.

TALL MEADOW OAT GRASS *(Arrhenatherum avenaceum.)*

Planted in 1896 but did not come up till 1897 and only made a scattering stand; consequently the yield obtained was light, it being only 1,584 pounds cured hay per acre in 1899. Owing to the fact that it attains a height of between three and four feet comparatively early in the season and does not require an excessive amount of water, it may prove of value to use as a mixture with alfalfa.

TIMOTHY *(Phleum pratense.)*

This has been given careful trial since 1891 on the Station Farm. We find that on high open places exposed to the drying winds of winter which prevent snow remaining long on the ground, timothy does not do well. It does not seem to grow vigorously and is apt to winter kill. One plat yielded at the rate of 2,444 pounds of cured hay per acre in 1898 and 1,080 pounds in 1899. It can be recommended for meadows which are kept comparatively wet.

MILLET *(Panicum milaceum.)*

No. 2795 from the United States Department of Agriculture yielded 3,569 pounds per acre of cured hay in 1899. The seed was sown very thickkly. The plants were frosted August 24 before they matured. A number of kinds of millet have received trials but the season at this altitude is not long enough for them.

HAIRY OR SAND VETCH *(Vicia villosa.)*

1898—Planted May 11 and 13 with oats. One plat yielded 4,666 pounds per acre and the other plat gave a yield of 4,659 pounds per acre of cured hay. This yield was oats and vetch. A second cutting of the vetch was made in September, giving a yield of 888 pounds per acre.

1899—Yielded 1174 pounds per acre on August 7. About one-half the plants were killed during the winter.

The Station received on March 1, 1897, seeds of one hundred thirty-five different forage plants from the Division of Agrostology of the United States Department of Agriculture. These consisted principally of native grasses collected in and adjacent to the Rocky Mountains. As only small amounts of seed were received only small plats could be planted. A portion of Acre Plat 16 on the Farm was laid aside for the work and carefully prepared. Plats three by three feet, or containing nine square feet, were laid out with paths two feet wide on two sides and one and one-half feet wide on the other two sides of each plat.

On July 15, 16 and 17 the seeds were planted by hand and carefully raked in. Begining on July 17, the plats were watered with a sprinkling pot night and morning, except when it rained, for one or two weeks, or until the majority of the plants were up. On August 18, banks were laid up on the paths running north and south so that bed irrigation could be practiced with each tier of plats. The plats were then irrigated on the following dates: August 18, 24 and September 4. In 1898 the plats received thorough irrigations on June 16, July 2, July 25, September 2 and September 16. In 1899 the plats were irrigated June 10, August 4 and 5 and September 28.

The following is a list of the forage plants sown, together with notes on their growth and condition in 1898 and 1899, respectively. In reporting the height and length of heads the meter is the unit of measure used. The yield per acre is computed in some instances, which will be, of course, only approximately correct, on account of the extremely small area of the plats, nine square feet in each.

Agropyron acutum (Europe.)

1898—

Aug. 3, fair stand; fully headed; height, 1.08 m.; cut, weight, cured, 1 lb., 8.5 oz.

1899—

June 9—Good stand.

July 14—Beginning to head.

Aug. 8—Height, 1.05 m.; fair stand; just starting to change color at the tips of the heads; cut; weight, green, 2.5 lbs; weight, cured, 1 lb. 3 oz.; 2.8 tons cured hay per acre.

Agropyron caninum R. & S.

1898—

Aug. 3—Good stand; fully headed; height, 1 m.; cut; weight, cured, 2 lbs., 3.8 oz.

1899—

June 9—Good stand.

July 20—Heading.

Aug. 21—Beginning to ripen; fair stand but only headed around the edges; height at edges, 0.46 m.; cut: weight, green, 1 lb, 15 oz.; 4.6 tons green fodder per acre; 2.3 tons cured hay per acre.

Agropyron divergens.

1898—

Fair stand: fully headed; height, 0.8 m.; cut: weight, cured, 10 oz.

1899—

July 7—Headed: varies in height.

July 25—Height, 0.55 m.; length of heads, 0.15 m.; good stand; yellowing; cut; weight, green, 1 lb.; weight, cured, 8.5 oz.; 1 1-3 tons cured hay per acre.

Agropyron pseudorepens.

1898—

The grass growing is evidently not the species named.

Agropyron repens, Beam.

1898—

Aug. 3—Headed; good stand; height, 0.75 m.; cut; weight, cured, 3 lbs., 6 oz.

1899—

Aug. 8—Heading; height very uneven.

Sept. 26—Ripened by frost; headed on edges of plat, not in center; height on edges, 1.2 m.; cut; weight, green, 2 lbs., 12 oz.; weight, cured, 1 lb., 9 oz.; 3.8 tons cured hay per acre.

Agropyron richardsonii, School.

1898—

Aug. 3—Good stand; headed; cut; weight, cured, 2 lbs., 5 oz.

1899—

July 20—Headed around edges of plat.

Aug. 21—Heads changing color; poor to fair stand; height, 0.6 m.; cut; weight, green, 2 lbs., 2 oz.; weight, cured, 1 lb., 3.5 oz.; 2.9 tons cured hay per acre.

Agropyron spicatum, S. & S.

1898—

Aug. 3—Good stand; headed; height, 0.6 m.; cut; weight, cured, 1 lb.

1899—

Sept. 26—Not headed; fair stand; height, 0.18 m.; not cut.

Agropyron tenerum, Vasey.

1898—

Aug. 3—Very good stand; lower leaves much thicker than on the other agropyrons; headed; height, 1 m.; cut; weight, green, 3 lbs.

1899—

July 24—Heading around edges of plat.

Aug. 21—Heads changing color some; good stand but few heads in center of plat; height, 0.7 m.; cut; weight, green, 1 lb., 7 oz.; weight, cured, 14 oz.; 2.1 tons per acre of cured hay.

Alopecurus occidentalis.

1898—

Aug. 3—Only two or three small plants; ripe; height, 0.53 m.; cut; weight, cured, 1.5 oz.

1899—

June 9—Headed.

July 7—Stand thin; only a few stems; seeds starting to ripen; height, 0.43 m.; length of heads, 0.015 m.; weight, cured, 1 oz.

Andropogon cinhatus.

Dead.

Andropogon nutans avenacens, Hack.

Dead.

Andropogon provincialis, L. *(A. furcatus,* Muhl.)

Dead.

Andropogon scoparius.

Dead.

Arrhenatherum elatius, M. & K.

1898—

Aug. 3—Badly mixed; two distinct varieties; cut together; weight, cured, 2 lbs.

1899—

July 7—Headed; two species mixed.

July 25—Good stand; height, 0.95 m.; cut; weight, green, 1 lb., 12.5 oz.; cured, 12.5 oz.; 1.9 tons cured hay per acre.

Arundinaria macrosperma, Michx.

Dead.

Astragalus carolinianus, L.

Never came up.

Astragalus crassicarpus, Nut.

Never came up.

Atriplex canescens, James.

Dead.

Atriplex halimoides.

Dead.

Atriplex leptocarpa.

Dead.

Atriplex nummularia.

Dead.

Atriplex semibaccata.

Dead.

Atriplex truncata.

Dead.

Australia Old Man Salt Bush.

Never came up.

Beckmannia erucaeformis, Host.

1898—

Aug. 3—Headed; poor stand; starting to ripen; height, 0.53 m.; cut; weight, cured, 5.3 oz.

1899—

Dead.

Bigelovia graveoleus albicaulis.
Never came up.

Bouteloua eriopoda, Torr.
Dead.

Bouteloua juncifolia, (H. B. K.) Lag.
Dead.

Bouteloua microstachya.
Dead.

Bouteloua oligostachya, Torr.
1898—
Aug. 3—Fairly good stand; not headed; height, 0.1 m.
1899—
July 14—Fair stand; short tufted; height, 0.06 m.
Sept. 26—Has not grown since July 14 in center of plat: an occasional head near edges of plat; height here about 0.4 m.

Bouteloua racemosa, Lag.
Dead.

Bouteloua rothrockii, Vasey.
Dead.

Bromus adoensis.
Dead.

Bromus carinatus.
Dead.

Bromus ciliatus, L.
1898—
Aug. 3—Good stand: headed: height, 0.8 m.: weight, cured, 1 lb., 10.5 oz.
1899—
July 7—Edges heading; center of plat not heading.
Aug. 8—Height, 0.7 m.; changing color: cut: weight, green, 2 lbs; cured, 15 oz.

Bromus inermus, Leys.

1898—

Aug. 3—Very good stand; partially headed; a thick mat of grass; cut; height, 0.9 m.; weight, cured, 1 lb., 14.5 oz.

1899—

July 7—Heading.

Aug. 8—Heads not abundant; changing color; height, 0.8 m.; cut; weight, green, 2.5 lbs.; weight, cured, 1 lb., 1.5 oz.; 2.6 tons cured hay per acre.

Bromus purgans.

1898—

Aug. 3—Headed; good stand; height, 0.92 m.; cut; weight, cured, 1 lb., 4.7 oz.

1899—

July 7—Headed on edges of plat.

July 20—Well headed.

Aug. 8—Changed color some; height, 0.75 m.; cut; weight, green, 1 lb., 12 oz.; weight, cured, 13 oz.; 2.0 tons cured hay per acre.

Bromus tectorum, L.

1898—

Aug. 3—Very fine stand; fully headed and ripe; height, 0.6 m.; cut; weight, cured, 4 lbs., 8.5 oz.

1899—

July 1—Headed; spreading out larger than the original plant.

July 25—Height, 0.55 m.; cut; weight, green, 5 lbs.; weight, cured, 2 lbs., 6.5 oz.; 5.8 tons cured hay per acre.

Bromus unioloides.

Dead.

Bulbilis dactyloides, Raf.

Dead.

Calamagrostis canadensis.
Never came up.

Calamagrostis confinis.
Never came up.

Calamagrostis dubia.
Dead.

Calamagrostis purpurascens.
1898—
Aug. 3—A few small plants not yet headed; height about .13 m.
1899—
July 7—Headed; height, 0.35 m.
Aug. 8—Species mixed; plat not cut.

Calamovilfa longifolia.
1898—
Sept. 26—Poor stand.
1899—
Dead.

Carex straminea.
Dead.

Chaetochloa glauca.
Dead.

Chloris elegans.
Never came up.

Chloris verticillata.
Dead.

Dalea alopecuroides.
Dead.

Dasylirion texanum, Sotol.
Never came up.

Deschampsia caespitosa, Beauv.

1898—

Aug. 3—A few plants not yet headed; about 0.5 m. high.

1899—

July 7—Headed.

Aug. 8—It is doubtful if this is the species named; ripe; height, 0.45 m.; was not cut.

Desmodium tortuosum.

Dead.

Eatonia obtusata.

1898—

Aug. 3—Two or three plants headed; height, 0.6 to 0.7 m.; cut; weight, cured, 1.3 oz.

1899—

July 7—Heading.

Aug. 8—Nearly ripe; poor stand; height, 0.62 m.; cut; weight, cured, 3 oz.

Eleusine australis, Scribn.

Never came up.

Elymus canadensis, L.

1898—

Aug. 3—Very good stand; headed; height, 0.9 m.; cut; weight, cured, 5 lbs., 9 oz.

1899—

July 14—Good stand.

Aug. 8—Heading.

Sept. 16—Seed ripe; probably hastened by frost; is about the same height in center of plat as on edges, which is not the case with most of the species in experiment; height, 1.1 m.; cut; weight, green, 3 lbs., 10 oz.; weight, cured, 2 lbs., 9 oz.; 6.0 tons cured hay per acre.

Elymus canadensis glaucifolius.

1898—

Aug. 3—Fair stand.

Aug. 29—Headed; height, 1 m.; length of heads, 0.14 m.; cut; weight, cured, 1 lb., 8 oz.

1899—

Sept. 26—Headed; still green; height, 1 m.; cut; weight, green, 2 lbs., 1 oz.; weight, cured, 1 lb., 5 oz.; 3.1 tons cured hay per acre.

Elymus giganteous (Europe).

1898—

Aug. 3—Very good stand; headed; height, 1 m. to 1.2 m.; cut; weight, cured, 3 lbs., 13.7 oz.

1899—

July 14—Good stand; apparently a promising plant.

Aug. 8—Heading.

Sept. 26—Heads ripened by frost; height, 1 m.; cut; weight, green, 4 lbs., 11 oz.; weight, cured, 2 lbs., 13.5 oz.

Elymus glaucus, Buckl.

Never came up.

Elymus virginicus, L.

1898—

Aug. 3—Very good stand; just starting to head.

Aug. 15—Height, 0.83 m.; cut; weight, cured, 2 lbs., 11.5 oz.

1899—

July 14—Good stand; abundant foliage.

Sept. 26—Headed; still green; height, 0.7 m.; cut; weight, green, 3 lb., 13.5 oz.; weight, cured, 8.5 oz.; 6.1 tons cured hay per acre.

Emotia lanata, L.

Dead.

Eragrostis abyssinica, Teff.

Dead.

Eragrostis purshii.

Dead.

Eragrostis major.

Never came up.

Eragrostis neo-mexicano.

Dead.

Eragrostis pilosa.

Dead.

Eragrostis tenulis, A. Gray

Dead.

Erodium cicutarium, Alfilaria.

Never came up.

Euchlaena mexicano.

Dead.

Festuca arundinacea.

1898—

Aug. 3—Fine stand; leaves thick; height, 1.1 m.; cut; weight, cured, 2 lbs., 15.5 oz.

1899—

July 7—Heading along edges of plat.

July 14—Good stand.

Aug. 8—Comparatively few heads for amount of foliage; heads changing color; height, 0.8 m.; cut; weight, green, 3 lbs.; weight, cured, 1 lb., 1.5 oz.

Sept. 26—Second growth about 0.2 m. high; 2.6 tons cured hay per acre.

Festuca fenas.

1898—

Fine stand; an occasional head; forms a thick mat on the ground.

1899—

July 20—Well headed.

July 25—Height, 0.6 m.; fine stand; closely matted: cut; weight, green, 1 lb., 4 oz.; weight, cured, 10 oz.

Sept. 26—Thick second growth; would make fine winter pasture; not high enough to cut, being about 0.2 m.

Festuca ovina arizonica.

1898—

Aug. 3—Poor to fair stand; not headed.

1899—

July 7—Heading on edges of plat.

July 20—Height, 0.65 m.; good stand; cut; weight, green, 12.5 oz.; weight, cured, 7.5 oz.

Sept. 26—Small second growth; 1.1 tons cured hay per acre.

Festuca ovina duriuscula.

1898—

Aug. 3—Good stand; height, 0.3 m.

1899—

June 9—Headed.

July 7—Tips of heads beginning to change color; height, 0.42 m.; weight, green, 1 lb., 2 oz.; weight, cured, 9 oz.

Sept. 26—Second growth forms short, thick mat; 1.3 tons cured hay per acre.

Festuca ovina duriuscula (Second plat).

1898—

Poor to fair stand; forms a thick mat where plants are; an occasional head; height, 0.35 m.

1899—

June 9—Headed.

July 7—Height, 0.4 m.; cut; weight, green, 1 lb., 3 oz.; weight, cured, 8.5 oz.

Sept. 26—Small second growth; 1.3 tons cured hay per acre.

Festuca ovina salcata.

1898—

Aug. 3—Good stand; forms a thick mat; an occasional head; height, 0.37 m.; cut; weight, cured, 6.3 oz.

1899—

June 9—Headed.

July 7—Height, 0.34 m.; same all over plat; length of heads, 0.05 m.; cut; weight, green, 12.5 oz.; weight, cured, 6 oz.

Sept.26—Small second growth; 0.9 tons cured hay per acre.

Festuca ovina, var. (Europe.)

1898—

Aug. 3—Fair stand; not headed; forms a rather thick mat.

1899—

July 7—Headed; cut; weight, green, 12 oz.; weight, cured, 5 oz.

Sept. 26—Good second growth; 0.7 tons cured hay per acre.

Festuca ovina, L. var.

1898—

Aug. 3—Fair stand; not headed.

1899—

July 7—Headed; changing color; stand thin; mixed with other grasses; height, 0.5 m.; length of heads, 0.075 m.; cut; weight, green, 5 oz.; weight, cured, 4.5 oz.

Sept. 26—Good second growth; 0.6 tons cured hay per acre.

Festuca pratensis.

1898—

Aug. 3—Very good stand; headed and about ripe; height, 0.77 m.; cut; weight, cured, 2 lbs., 11 oz.

1899—

July 7—Heading.

July 25—Height, 0.75 m.; length of heads, 0.17 m.; good stand; cut; weight, green, 2 lbs., 8 oz.; weight, cured, 1 lb.; 2.4 tons cured hay per acre.

Festuca rubra glaucescens.

1898—

Aug. 3—Poor stand; thick mat; starting to head; height about 0.48 m.

1899—

July 7—Headed.

July 14—Grows in thick clumps.

Aug. 8—Changing color; height, 0.45 m.; cut; weight, green, 1.5 lbs.; weight, cured, 10.5 oz.

Sept. 26—Good second growth; 1.5 tons cured hay per acre.

Glyceria aquatica.

Dead.

Glyceria nervata.

Never came up.

Glycine hispida.

Dead.

Glycynliza lepidota.

Never came up.

Hilaria cenchroides.

Dead.

Hilaria jamesii.

Never came up.

Hilaria rigida.

Never came up.

Hordeum adscendens.

Dead.

Hordeum bulbosum.

1898—

Aug. 3—Poor to fair stand; headed; height, 0.89 m.; cut; weight, cured, 9 oz.

1899—

Dead

Hordeum chilense.

1898—

Aug. 4—Poor stand; headed; height, 0.28 m.; cut; weight, cured, 1.8 oz.

1899—

No notes.

Hordeum pratense.

1898—

Aug. 4—Poor stand; headed; height, 0.4 m.; cut; weight, cured, 3.5 oz.

1899—

No notes.

Hosackia purshians.

Never came up.

Koeleria cristata.

1898—

Aug. 4—Poor to fair stand; headed; height, 0.35 m.

1899—

July 7—Headed.

July 25—Height, 0.38 m.; length of heads, 0.09 m.; makes a poor general showing; cut; weight, green, 10.5 oz.; weight, cured, 6 oz.; 0.9 tons cured hay per acre.

Koeleria nitida.

1898—

Aug. 4—Poor stand; headed; height, 0.35 m.

1899—

July 7—Fully headed; height, 0.38 m.

July 20—Cut; weight, green, 8 oz.; weight, cured, 5 oz.

Koeleria valesiaca.

1898—

Aug. 4—Poor stand; only four or five plants; apparently not very thrifty.

1899—

July 7—Headed; height, 0.25 m.; very poor stand; not cut.

Leptochloa imbricata.

Dead.

Lolium perenne.

1898—

Aug. 15—Good stand; well headed; height, 0.65 m.; cut; weight, cured, 1 lb., 1 oz.

1899—

July 24—Very poor stand; a few beginning to head.

Sept. 26—Not over twenty heads in all; fully ripe; height, 0.5 m.; cut; weight, green, 6 oz.; weight, cured, 3.5 oz.

Lycurus phleoides, H. B. K.

Dead.

Lygeum spartum.

Dead.

Melica altissima.

1898—

Aug. 4—Three or four plants; headed; height, 0.45 m.

1899—

July 14—Only four bunches in all; well headed; heads whitening; height, 0.75 m.; was not cut.

Muhlenbergia racemosa.

1898—

Good stand; not headed.

1899—

July 14—Good stand.

Sept. 26—Still green; yellowing from frost; height, 0.5 m.; cut.

Polygonum ramosissimum.

Never came up.

.*Panicularia aquatica.*

1898—

Aug. 4—Poor stand; not thrifty; not headed.

1899—

Dead.

Panicum colonum.

1898—

Aug. 4—One or two plants that may be the species planted.

1899—

July 7—One bunch that may be the species; headed; height, 0.6 m.

Panicum crusgalli.

1898—

Aug. 4—A few plants; not tillered; not headed.

1899—

Dead.

Panicum frumentaceum.

Dead.

Panicum texanum.

1898—

Aug. 8—One plant that may be the species.

1899—
Dead.

Panicum virgatum.
Never came up.

Paspalum dilatatum.
Dead.

Paspalum pubiflorium globrum.
Never came up.

Pencedanium. sp. (*Kooma* from mountains in Persia.)
Never came up.

Phalaris arundinacea.
Never came up.

Phalaris caroliniana, Walt. *(P. intermedia.)*
1898—
Aug. 4—Poor stand; headed and ripening; height. 0.42 m.; cut; weight, cured, 1.5 oz.
1899—
Dead.

Poa arachnifera.
1898—
Aug. 4—One or two plants that may be the species; not headed.
1899—
Dead.

Poa buckleyana.
1898—
Aug. 4—Poor stand; headed; about ripe; height. 0.43 m.
1899—
July 7—Headed.
July 14—Stalks whitening.
July 20—Height. 0.7 m.; fair stand; cut; weight. green. 1 lb., 5 oz.; weight, cured. 10 oz.; 1.5 tons cured hay per acre.

Poa compressa.

1898—

Aug. 4—Good stand; height, 0.35 m.

1899—

July 7—Headed on edges of plat.

July 20—Height, 0.53 m.; good stand; thickly matted at base; cut; weight, green, 1 lb., 1 oz.; weight, cured, 10.5 oz.

Sept. 26—Fairly good second growth; 1.5 tons cured hay per acre.

Poa fertilis.

1898—

Aug. 4—Poor stand; headed; height, 0.7 m.; cut; weight, cured, 8 oz.

1899—

July 7—Heading; poor stand, but matted well in places; leaves grow well up on stem, which would be a good characteristic for hay.

July 25—Height, 0.62 m.; length of heads, 0.24 m.; cut; weight, green, 1 lb., 3 oz.

Sept. 26—Good second growth.

Poa pratensis.

1898—

Aug. 4—Good stand; headed.

1899—

July 7—Headed on edges of plat.

July 20—Height, 0.57 m.; thickly matted at base; cut; weight, green, 1 lb., 1 oz.; weight, cured, 10.5 oz

Sept. 26—Good second growth; 1.5 tons cured hay per acre.

Scirpus atrovirens.

Never came up.

Scirpus martimus.

Never came up.

Secale montanum.

1898—

Aug. 4—Fine stand; headed; height, 1 m.; this plat seems to have more vegetation on it than any in the experiment; cut; weight, cured, 7.8 oz.

1899—

July 14—Headed; good stand.

July 25—Height, 0.85 m.; length of heads, 0.1 m.; cut; weight, green, 4 lbs., 1 oz.; weight, cured, 1 lb., 9.5 oz.

Sept. 26—Good second growth.

Sporobolus asper.

1898—

Aug. 4—Good stand; not headed; height of leaves, 0.7 m.

1899—

Dead.

Sporobolus cryptandrus.

Never came up.

Sporobolus heterolepis.

Never came up.

Sporobolus wrightii.

Dead.

Stipa robusta.

1898—

Aug. 4—Fair stand; headed; height, 1 m.; cut; weight, cured, 14 oz.

1899—

July 14—Fair stand.

Aug. 8—Heading.

Sept. 26—Height, 1 m.; did not head freely; leaves form a thick mat about 0.15 m. high; cut; weight, green, 1 lb.; weight, cured, 10 oz.; 1.5 tons cured hay per acre.

Stipa viridula.

1898—

Aug. 4—Fair stand; heading; height, 0.7 m.; cut; weight, cured, 5.5 oz.

1899—

July 7—Heading.

Aug. 8—Ripe and shattering; seems to be mixed with another variety; height, 0.8 m.; by mistake was not cut until Aug. 21, so heads are badly dried out; weight, green, 1 lb., 6 oz.; weight, cured, 12 oz.; 1.8 tons cured hay per acre.

Thermopsis montana.

Never came up.

Trifolium beckwithi.

Never came up.

Trifolium longipes.

Never came up.

Triticum villosum.

1898—

Aug. 4—Headed and ripening; poor stand; height, 0.6 m.; cut; weight, cured, 6.5 oz.

1899—

Dead.

Vicia villosa.

1898—

Aug. 4—Fine stand; in bloom and pods forming; length of vine, 1.3 m.; cut; weight, cured, 8 lbs.

1899—

Dead.

Zoysia pungens.

Never came up.

LIST OF FORAGE PLANTS WHICH HAVE SHOWN THEMSELVES WORTHY OF FURTHER TRIAL.

Agropyron acutum.
A. caninum.
A. divergens.
A. repens.
A. richardsonii.
A. spicatum.
A. tenerum.
Bromus ciliatus, L.
B. purgans.
B. tectorum, L.
Elymus canadensis, L.
E. canadensis glaucifolius.
E. giganteus (Europe.)
E. virginicus, L.
Festuca arundinacea.
F. fenas.
F. ovina arizonica.
F. ovina duriuscula.
F. ovina salcata.
F. ovina var. (Europe.)
F. ovina, L. var.
F. pratensis.
F. rubra glaucescens.
Lolium perenne.
Poa buckleyana.
P. compressa.
P. fertilis.
P. pratensis.
Secale montanum.
Stipa robusta.
S. viridula.
Vicia villosa.

LIST OF FORAGE PLANTS WHICH HAVE BEEN TRIED BUT WHICH HAVE NOT YET FURNISHED SUFFICIENT DATA FROM WHICH TO DETERMINE THEIR USEFULNESS OR USELESSNESS.

Agropyron pseudorepens.
Alopecurus occidentalis.
Andropogon cinhatus.
    A. nutans avenacens.
    A. provincialis, L.
    A. scoparius.
Arrhenatherum elatius, M. & K.
Anthyllis vulneraria, (Kidney Vetch.)
Astragalus carolinianus, L.
    A. crassicarpus, Nut.
Atriplex canescens, James.
    A. halimoides.
    A. leptocarpa.
    A. nummularia.
    A. truncata.
Beckmannia erucaeformis.
Bouteloua eriopoda, Torr.
    B. juncifolia (H. B. K.) Lag.
    B. microstachya.
    B. oligostachya, Torr.
    B. racemosa, Lag.
    B. rothrockii, Vasey.
Bromus adoensis.
    B. carinatus.
    B. unioloides.
Bulbilis dactyloides, Raf.
Calamagrostis canadensis.
    C. confinis.
    C. dubia.
    C. purpurascens.

Calamovilfa longifolia.
Carex straminea.
Chaetochloa glauca.
Chloris elegans.
C. verticillata.
Dalea alopecuroides.
Dasylirion texanum, Sotol.
Deschampsia caespitosa.
Eatonia obtusata.
Eleusine australis, Scribn.
Elymus glaucus, Buckl.
Emotia lanata, L.
Eragrostis abyssinica, Teff.
E. purshii.
E. major.
E. neo-mexicano.
E. pilosa.
E. tenulis, A. Gray.
Erodium cicutarium, Alfilaria.
Euchlaena mexicano.
Glyceria aquatica.
G. nervata.
Glycine hispida.
Glycynliza lepidota.
Hilaria cenchroides.
H. jamesii.
H. rigida.
Hordeum adscendens.
H. bulbosum.
H. chilense.
H. pratense.
Hosackia purshians.
Koeleria cristata.
K. nitida.
K. valesiaca.

Leptochloa imbricata.
Lycurus phleoides, H. B. K.
Lygeum spartum.
Melica altissima.
Muhlenbergia racemosa.
Polygonum ramosissimum.
Paniculuria aquatica.
Panicum colonum.
  P. crusgalli.
  P. frumentaceum.
  P. texanum.
  P. virgatum.
Paspalum dilatatum.
  P. pubiflorium globrum.
Pencedanium sp. ("Kooma" from mountains in Persia.)
Phalaris arundinacea.
  P. caroliniana, Walt.
Poa arachnifera.
Scirpus atrovirens.
  S. maritimus.
Sporobolus asper.
  S. cryptandrus.
  S. heterolepis.
  S. wrightii.
Thermopsis montana.
Trifolium beckwithi.
  T. longipes.
Triticum villosum.
Zoysia pungens.

LIST OF FORAGE PLANTS WHICH HAVE PROVEN THEMSELVES USELESS UNDER THE CONDITIONS OF CLIMATE AT OUR HIGH ALTITUDE.

Arundinaria macrosperma.
Atriplex semibaccata.
Glycine hispida.
Desmodium tortuosum.
Trifolium incarnatum.
Polygonum sachilense.
Cow pea.
Millet.
Spurrey—Sperglua arvensis.
Serradilla.

Variety Tests of Wheat, Oats and Barley

By B. C. BUFFUM and W. H. FAIRFIELD.

PUBLISHED AS PART OF THE TENTH ANNUAL REPORT OF THE
WYOMING EXPERIMENT STATION.

JULY, 1900.

LARAMIE, WYOMING.

Variety Tests of Wheat, Oats and Barley.

BY B. C. BUFFUM AND W. H. FAIRFIELD.

The average altitude of the agricultural land in Wyoming is said to be about 6,000 feet and it is certain that the larger part of the state is more than a mile above the sea. On the high plateaus the season is very short and we early saw the value of finding grain which would produce heavy yields under our conditions and ripen with certainty. The land is fertile and grains succeed admirably if the right varieties are planted. Oats are more extensively grown than any other grains and in order to plant oats it has been necessary for the farmer to purchase whatever was on the market for seed. Very often the variety obtained is a late one and fails to ripen or to more than partially mature a crop. Before the farmer can be sure of the greatest success, he must raise seed at home of kinds which are adapted to the region. In order to aid in doing this, we have given all the varieties which we could obtain, trial at Laramie. In 1896 Professor George Vestal of New Mexico kindly furnished us small amounts of seed of over 400 varieties of wheat, oats and barley. In 1898 Professor A. E. Blount, who had collected grains from all over the world for many years, and who was himself the originator of a number of first-class varieties of wheat and oats, most generously sent us his whole collection. The wheats were planted in the fall, but our winters are too dry for winter grain, and none of this fall planting lived over. We had saved a part of the seed of every variety and it was planted the next spring. We also received in 1896 collections from Professor

R. H. McDowell of Nevada, Professor W. W. Cooke of Colorado, and others. Short rows of the varieties received from New Mexico, Nevada and Colorado were grown on the Experiment Farm in 1896 and 1897 and the collection received from Professor Blount was grown in 1898 and 1899. The results are reported in the following tables, from which the varieties which are most promising for larger field trials may easily be selected.

In 1896 all the wheats, oats, and barleys were planted April 20 to 24; in 1897 on May 1; in 1898 on April 16, and in 1899 on May 6. A killing frost usually occurs about September 10, so that varieties that are not nearly matured at this date do not make a profitable crop.

TABLE I.—*Wheat, 1896.*

This gives the results of wheats grown, from seed furnished by Professor Vestal of New Mexico, during the season of 1896. One row 50 feet long of each variety was planted. The rows were 18 inches apart.

No.	NAME	Date headed	Date ripe	Height	Length of head	Yield of straw and grain from 50 feet of row		Yield of grain from 50 feet of row	
				feet	*feet*	*lbs.*	*oz.*	*lbs.*	*oz.*
1	Minnesota Fife	July 28	Sept. 14	3.6	0.32	10	14	2	14
2	White Fife	Aug. 8	" 18	3.9	0.35	12	7	3	9
3	Sherman	July 25	" 12	3.7	0.3	14	7	4	5
4	White Russian	" 27	" 17	3.5	0.28	12	1	3	12
5	Odessa		" 14	3.45	0.38	12	12	1	14
6	Eldorado	" 27	" 14	4.0	0.26	8	14	2	5
7	Soft Australian	Aug. 1	" 15	3.85	0.3	8	10	2	15
8	Defiance	July 29							
9	Champion	" 25	" 12	3.7	0.35	14	5	4	1
10	Oregon Club		" 18	3.4	0.26	10	14	3	4
12	Sonora		" 14	3.0	0.3	6	9	2	9
13	White Mexican	" 27	" 18	3.55	0.35	11	7	5	11
14	Improved Fife		" 15	3.6	0.3	10	4	2	7
16	Brooks	Aug. 1	" 16	3.6	0.3	9	5	2	7
17	Rio Grande	July 29	" 14	3.6	0.35	13	3	1	7 5
18	Canada Club	" 23	" 11	3.3	0.27	23	9	5	10
19	Judkin	" 29	" 15	2.65	0.36	10	3	2	10
20	Lost Nation	Aug. 10	" 14	3.75	0.4	13	7	3	6
21	Touzelle		" 12	3.75	0.3	15	7	4	8
22	Australian Club	July 29	" 16	3.75	0.3	13	14	4	11
25	China Tea	" 29	" 16	3.9	0.4	10	6	2	11
26	Chili	" 29	" 18	3.8	0.25	10	12	3	3
28	Egyptian	" 25	" 15	3.9	0.28	13	7	3	12
29	Saxon Fife		Oct. 8	4.0	0.33	10	6	1	15
30	Dominion		" 5	4.0	0.35			1	1
31	Prussian	" 27	Sept 12	3.3	0.25	14	6	4	1

TABLE I (Continued).—*Wheat, 1896.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of straw and grain from 50 feet of row		Yield of grain from 50 feet of row	
				feet	*feet*	*lbs.*	*oz*	*lbs.*	*oz.*
32	Golden Drop		Sept. 18	3.8	0.3	15		4	8.5
33	Pringle's No. 6	July 31	" 12	3.6	0.3	13	4	4	
34	" No. 4	Aug. 6	" 17	3.88	0.34	13	6	3	11
35	" No. 5	" 8	" 14	3.9	0.35	13	3	3	6
38	Fultz	Sept. 16		3.7	0.33				
40	Black Centennial	July 31	" 12	3.9	0.35	14	10	3	9
41	Hedgerow	" 27	" 18	3.4	0.14	12	9	4	7
42	Granite	Aug. 6	" 16	4.0	0.35	12	5	3	11
43	Italian	July 29	" 18	3.85	0.28	12	12	4	
44	New York Flint	Aug. 10	" 17	3.9	0.33	26	2	5	8
45	Bald Baltic	July 29	" 12	3.85	0.3	16	5	5	10
48	Red Orange		" 14	3.7	0.36	14	9	3	7
51	Hybrid No. 10	Aug. 13	" 18	3.8	0.35	15	8	4	12
54	Velvet Chaff		Oct. 8	4.2	0.35	6	14	1	3
55	Turkey	July 29	Sept. 18	3.9	0 3	14		4	1
56	Sardonyx		Oct. 8	4.2	0.4	12	9	1	12
57	Amethyst	" 31	Sept. 15	3.7	0.3	10	1	3	1
58	Ruby		" 18	4.0	0.34	9	6	1	13
62	Emerald								
63	Black Chaff	Aug. 8	" 16	3.4	0.3	10	1	1	8
64	Cretan	July 27	" 18	4.1	0.25	12		3	11
70	Anautka	" 25	" 12	3.6	0.2	11	7	4	3
71	Fountain	Aug. 6	" 18	4.0	0.3	14	3	4	9
72	Palestine	" 6	" 18	4.15	0.35	17	2	4	9
73	White Chaff (smooth)	July 29	" 14	3.7	0.3	14	5	4	7
74	" " (bearded)	" 31	" 12	3.4	0.33	16	4	5	6.5
76	Perfection	Aug. 6	" 23	3.55	0.3	12	15	4	9
77	German Fife	" 8	" 12	4.0	0.4	15	7	4	2
78	Mammoth		Oct. 8	4.0	0.36	9	14	1	7
79	*Triticum								
80	Samara	July 25	Sept. 16	4.5	0.27	11	7	5	4
81	Durum	" 29	" 18	4.1	0.3	14	11	5	3
84	Moscow	" 27	" 18	3.6	0.3	13	3	4	4
85	Knapp	" 29	" 18	3.6	0.27	17	3	5	6
87	Doty	" 27	" 12	3.7	0.3	13	5	3	11
89	White Michigan		" 14	3.36	0.3	11	11	2	5
90	Rickenbrode	Aug. 8	" 16	3.5	0.33	9	6	2	5
91	Red Siberian		" 17	3.5	0.35	17	6	3	11
94	*Rice								
95	*Swamp								
96	*Golden Medal								
97	*Glass								
98	*German Amber			4.26					
99	*Wysor								
100	Dallas		" 15	3.6	0.34	10	9	2	10
101	*Champion Amber								
102	*Finlay		" 26	4.2	0.3				
103	*Lemon								
104	*McGee's Red								
105	*Bennet								
106	*Early May								
107	*Rocky Mountain								
108	*Silver Chaff								
110	Propoe	July 31	" 12	3.7	0.3	13	1	4	
111	*Small Frame								

*This is a winter variety.

TABLE I (Continued).—*Wheat, 1896.*

No.	NAME.	Date headed	Date ripe	Height	Length of heads	Yield of straw and grain from 50 feet of row		Yield of grain from 50 feet of row	
				feet	*feet*	*lbs.*	*oz.*	*lbs.*	*oz.*
112	*Red Clawson								
113	*Yellow Missouri								
114	*Walker								
116	*Zimmerman								
117	Big May		Oct. 8	4.5	0.3	15		2	8
118	Sardius		Sept. 14	4.6	0.33	8	11	2	1
119	Chrysolite	July 31	" 18	3.9	0.33	15	6	4	7
120	Beryl	" 29	" 16	3.3	0.28	8	9	1	15
122	Jacinth	" 27	" 14	3.45	0.35	10	5	3	13
123	Carnelian		" 23	3.7	0.3	18	2	5	3
124	Agate	" 23	" 17	4.0	0.35	10	8	3	5
125	Onyx	Aug. 6	" 16	3.8	0.3	14	8	4	7
126	Opal		" 17	3.55	0.3	7	3	5	4
127	Garnet		" 16	3.8	0.4	9	13	1	11
131	Casaca		" 17	4.0	0.38	14	4	3	4
132	Califat								
133	Tuscan		" 15	3.6	0.27	8	15	1	4
134	*Essex								
136	*Pearl								
137	*Hunter's Winter								
138	White Chaff	July 25	" 18	3.9	0.33	13	2	4	2
139	Square Head Essex								
140	*Gold Drop								
145	Red Oregon Club	Aug. 6	" 16	3.8	0.27	10	10	3	7
146	Hedgerow	" 8	Oct. 8	3.9	0.15	11	11	2	14
147	Aowse	July 25	Sept. 16	4.0	0.25	14	11	3	14
148	Monmouth	" 31	" 12	4.0	0.35	16	3	4	4.5
149	Russian (Spring)	Aug. 8	" 14	3.8	0.4	14	1	3	3
150	Vermillion	July 27	" 14	3.4	0.35	13	13	4	6
151	Smoky	Aug. 8	" 14	3.7	0.35	15	12	4	11
152	Edmonton Fife		Oct. 8	4.0	0.35	15	11	1	10
153	Nox No. 2	July 29	Sept. 18	3.65	0.35	13	13	5	
154	" No. 1	" 29	" 15	3.7	0.33	6	10	2	6
156	" No. 3	Aug. 8	" 16	3.9	0.33	15	2	4	7
157	" No. 5	July 25	" 18	3.9	0.45	13	4	4	4
158	Pringle's No. 17		" 23	3.9	0.4	13	2	3	10
160	Wales	" 25	" 18	3.75	0.35	13	1	4	2
162	Northcote's White	Aug. 10	" 18	3.7	0.33	11		3	8
165	*Cat Mountain			4.0	0.35				
168	Black Chaff	July 31	" 12	3.9	0.35	14	10	3	9
169	Gneiss	Aug. 8	" 16	4.1	0.3	13	3	4	4
170	*Velvet Amber								
171	*Hebron		Oct. 8	5.3	0.33				
172	Quartz	July 17	Sept. 12	3.0	0.3	16	3	4	10
173	*White Mediterranean			4.6	0.35				
174	Red "		Oct. 7	3.5	0.3	16	9	2	6
176	Nebraska	" 27	Sept. 17	4.0	0.33	10	7	2	13
177	White's		" 12	4.2	0.4	11	10	1	12
178	*Kivet			3.8	0.33				
179	Rust Proof	Aug. 8	" 16	3.9	0.33	14	13	4	6
180	Baltimore		Oct 7	4.0	0.25	10	13	1	2.5
181	*Davis								
182	Purple Straw	" 10	Sept. 16	3.6	0.26	10	2	2	14
183	*Gold Premium								
184½	*			3.7	0.35				

*This is a winter variety.

TABLE I (Continued).— *Wheat, 1896.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of straw and grain from 50 feet of row		Yield of grain from 50 feet of row
				feet	*feet*	*lbs.*	*oz.*	*lbs.oz.*
185	*Earnhardt							
186	Wintergreen		Oct. 6	4.6	0.33	7	1	15
187	*St. Ledger							
188	Cheshire							
189	*Hunter's Spring			3.9	0.36			
190	*Oakchott's							
192	Geiger	July 29	Sept. 14	3.35	0.25	10	11	3 4
193	Hornblende	Aug. 8	" 16	4.1	0.35	15	8	4 11
195	Edmenton	" 6	" 12	3.9	0.3	14	2	4 2.5
196	Winnipeg Russian	" 6	" 18	3.9	0.28	10	15	2 15
198	Winnipeg		" 16	4.1	0.23	15	6	5 4
200	Hallett's Pedigree	July 29	" 18	3.8	0.3	16	8	4 10
201	Sibley's No. 1	Aug. 6	" 16	4.4	0.27	7	14	1 5
202	*French Black Chaff			3.7	0.3			
203	Rural	" 6	" 18	4.25	0.3	15	4	4 10
204	Velvet Club		Oct. 7	3.85	0.35	6	8	1 1
207	Whittington		" 8	4.2	0.33	1		9
208	Snowflake	July 31	Sept. 18	3.8	0.3	14		4 2
210	Tagarog	Aug. 8	" 18	4.0	0.33	21	1	6 2
211	*Michigan Amber							
214	*Missouri Turkey			3.0	0.3			
215	* " Mediterranean							
216	*California Walker							
218	*India Red							
219	Andrus Black		Oct. 8	4.2	0.3	17	12	1 7
220	*Mediterranean Hybrid							
221	*Andrus Flint							
222	Saskatchewan	July 3	Sept. 12	3.8	0.35	16	15	4 14
223	Rye	Aug. 6	" 12	4.5	0.35	14	7	2 14
224	Frankenstein	July 31	" 12	3.8	0.35	14	15	4 1
225	March	" 29	" 18	3.75	0.33	12	7	4 9
226	*Flanders		Oct. 7	3.5	0.33			
227	Flourelle		" 7	3.85	0.3	5	13	9
229	Circassian		" 7	3.7	0.3	12	15	1 5
230	White Velvet	" 31	Sept. 18	3.55	0.33	14	1	5 4
231	Verplank		Oct. 7	3.26	0.3	7	4	11
232	*Fenton							
234	Wicker	Aug. 6	Sept. 16	3.45	0.32	9	9	2 14
235	*Hopetown			3.8	0.3			
236	Talavera	" 8	" 17	4.15	0.45	14	9	4 2
238	Shumaker	July 29	" 14	3.6	0.35	13	3	2 1
240	Snake River		Oct. 6	4.0	0.33	13	6	3 4
241	Red River	" 25	Sept. 12	3.5	0.27	9	6	3 2
242	Upland	Aug. 6	" 14	2.85	0.33	9	2	2 7
243	Hard Manitoba	July 27	" 12	3.85	0.3	1	4	12
244	Santa Fe	Aug. 6	" 18	4.1	0.35	9	10	6
247	*Ostery							
249	Democrat							
250	*Buckeye							
251	*Nigger							
252	Armstrong	" 19	Not harvested					
253	Landreth							
254	*Red May							
255	Tasmanian Red							
256	*Wild Goose							

*This is a winter variety.

TABLE I (Continued).—*Wheat, 1896.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of straw and grain from 80 feet of row		Yield of grain from 80 feet of row	
				feet	*feet*	*lbs.*	*oz.*	*lbs.*	*oz.*
257	*Treadwell								
259	*Arnold's Hybrid		Sept. 12	3.5	0.3				
260	*Boyer								
261	*Canadian Express								
263	*Emporium								
264	*Hickman								
265	*Lincoln								
266	Michigan Wick		Oct. 8	4.1	2.33	5			14
268	*Powers								
269	*Red Sea								
270	*Roger's								
272	*Scott								
275	*White Rose								
276	*Menomite								
277	*Soule's								
278	*Hungarian								
280	Uxbridge	July 31	Sept. 12	4.1	0.3	1	2		11
283	Rust Proof (soft)	Aug. 10	“ 12	3.9	0.3	18	2	4	14
288	Dand Khan No. 2	July 17	“ 18	2.5	0.3	4	9	2	
291	*White Mountains								
292	*Fulcaster								
294	*Raub's Prolific								
297	*Crete								
299	*Tappahannock			4.0	0.27				
301	Basalt		Oct. 8	4.3	0.33	9		1	8
302	Flourspar	Aug. 6	Sept. 14	3.8	0.33	10	10	2	8
303	Granite	“ 6	“ 16	3.65	0.33	8	4	2	
304	Platinum		“ 17	3.5	0.27	8	12	1	13
305	Porcelain	“ 8	“ 18	3.9	0.38	10	6	2	2
306	Silica	July 17	“ 12	3.25	0.3	17		6	2
307	Trap		Oct. 8	4.25	0.35	10	5	1	7
309	Pool's Red	Aug. 10	Sept. 17	3.6	0.33	14	1	4	4
310	*Early Rice								
319	Deitz Red		Oct. 8	4.3	0.33	8	15	1	15
321	“ Amber		“ 7	1.198	0.33	13	15	1	1
328	*Gold Dust								
331	Weeks	“ 8	Sept. 17	3.15	0.3	9	11	3	9
332	Hoover		Oct. 7	3.7	0.32	12	14	3	8
333	*Winter Pearl								
334	*Valley			4.3	0.4				
336	Early Oakley		Sept. 18	4.1	0.33	14	2	2	15
337	Genoese	“ 6	“ 18	3.55	0.35	14	15	4	10
341	*Martin's Amber								
342	Indian	July 31	“ 14	3.5	0.25	10	2	3	7
343	*Sheriff (four-rowed)								
344	Baart	“ 25	“ 12	3.2	0.28	14	15	5	10
347	Ward's Prolific	Aug. 6	“ 16	3.4	0.33	8	12	3	5
348	Roseworthy		“ 5	1.9	0.25	6	13	2	7
349	Australian Purple Straw	“ 10	“ 15	3.6	0.3	15	10	4	13
353	*Landreth								
358	Rattling Tom	July 31	“ 18	4.0	0 35	14	4	3	10
359	Volo	“ 23	“ 15	3.8	0.2	12	2	2	15
360	Missogen		Oct. 6	4.15	0.43	12	3	3	5
361	Atlanti	“ 17	Sept. 18	3.25	0.2	15	2	6	4
363	Sadoza	“ 27	“ 16	3.7	0.3	5	15	1	5

*This is a winter variety.

TABLE I (Continued).—*Wheat, 1896.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of straw and grain from 50 feet of row		Yield of grain from 50 feet of row	
				feet	*feet*	*lbs.*	*oz.*	*lbs.*	*oz.*
364	Curtis' White	July 27	Sept. 14	3.6	0.35	8	14	2	4
367	*Improved Rice								
368	*Currat's Prolific								
370	*Egyptian No. 1								
386	*Pollard								
387	Russian Hard								
388	*Carter's A								
389	* " B			4.0	0.25				
390	* " C								
391	* " D								
392	* " E								
396	* " I								
397	* " J								
398	* " K								
399	*Northcote's Amber								
400	Algerian No. 1	" 27	" 16	3.95	0.3	11	4	5	8
401	" No. 2	" 25	" 12	3.4	0.2	11	3	4	14
402	" No. 3		Oct. 8	4.4	0.33	12	8	2	1
403	*Reiti		" 8	3.5	0.35				
404	*Galland Hybrid								
405	Zeland		Sept. 17	3.65	0.4	9	14	2	12
406	Lanneurde Mars		" 12	3.7	0.35	11	10	3	
409	Mold's Red			3.4	0.37				
411	*Hungarian			3.25	2.25				
412	Prize	" 25	" 16	3.95	0.27	9	1	2	11
413	Little Wonder		" 18	3.55	0.3	14	10	4	5
414	Champion	" 27	" 17	3.55	0.3	12	13	3	15
416	Oakshot's Champion	" 27	" 16	3.55	0.33	13	15	4	8
417	*Incomparable								
419	McDowell	" 27	" 12	3.6	0.27	16	6	5	8
420	Young's	" 27	" 17	4.0	0.3	19	2	7	10
421	California Red	" 17	" 12	2.85	0.27	9		3	9
422	Little Club	Aug. 8	" 23	3.4	0.17	8	9	3	6
425	Purple		" 12	3.8	0.3	19	7	5	13
426	Tuscan	" 6	" 16	3.8	0.35	9	14	2	15
427	Jubilee	July 25	" 16	3.6	0.35	15	6	4	11
428	Leake's	" 25	" 15	3.75	0.3	12	3	3	12
431	Rodi		" 12	3.0	0.3	12	5	4	8.5
432	Dera		" 14	3.0	0.27	8	10	3	1
433	Baggi	" 25	" 17	2.6	0.23	5	6	2	0
434	Ratti		" 14	3.0	0.25	8		3	1
435	Dorin		" 15	2.6	0.22	9	8	3	8
437	Walu		" 15	2.9	0.25	8	2	3	3
438	Lohi		" 18	3.0	0.25	8	7	2	14
439	Khel	" 25	" 16	2.7	0.26	7	1	3	1
440	Shega	" 22	" 16	3.0	0.28	7	15	3	4
441	Awal No. 1	" 17	" 12	2.9	0.2				
442	" No. 2	" 23	" 18	2.55	0.25	9	11	3	11
444	Archer's Prolific	" 25	" 15	3.0	0.28	10	14	4	8
446	Daub 1	" 27	" 17	4.25	0.3	8	5	2	5
447	Farrie's Durum								
448	Barwick	Aug. 8	" 18	3.26	0.35	13	11	5	1
449	*Early Jasper								
449½	Samara Club		" 14	3.6	0.32	15	14	4	10
450	Bancroft	July 27	" 17	2.75	0.22	7	8	3	6

*This is a winter variety.

TABLE I (Continued). *Wheat, 1896.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of straw and grain from 60 feet of row		Yield of grain from 60 feet of row	
				feet	*feet*	*lbs.*	*oz.*	*lbs.*	*oz.*
452	Banater	July 27	Sept. 18	2.9	0.24	16	12	1	6
453	Paros	" 27	" 18	3.8	0.23	17	7	5	4
454	Cape	" 31	" 14	3.1	0.25	8	15	2	11
456	Hudson's	" 27	" 12	3.25	0.28	11	10	4	0.5
457	Murray River	Aug. 6	" 18	4.1	0.33	15	7	5	8
458	Green Mountain	July 27	" 16	3.75	0.3	14	13	4	15
460	Cordova		" 17	3.8	0.42	9	14	2	6
461	Little Club		Oct. 6	3.2	0.2	11	1	2	14
463	Carter's 1		" 8	3.9	0.35	17	2	2	6
464	Laird's Prolific	July 27	Sept. 16	3.5	0.3	21	2	3	8
465	Borneo	" 25	" 18	3.9	0.3	13	15	4	12
467	*Veneta			3.7	0.35				
468	*Varlsotta			4.0	0.35				
470	Belolourka	" 25	" 16	4.0	0.23	14	1	4	8
471	Reiti 2		Oct. 6	4.15	0.36	14	4	1	13
472	Bordeaux	Aug. 8	Sept. 16	3.85	0.25	15	4	3	12
478½	Gypsum Fleck		Oct. 6	4.5	0.33	15	14	3	4
481	Northern Champion	" 8	Sept. 16	3.8	0.3	15	7	5	13
483		July 31	" 18	3.9	0.35				7
484			" 12	4.2	0.4	13	5	4	1.5
485		" 27	" 17	3.75	0.35	10	3	3	6
487		Aug. 6	" 17	3.26	0.16	9	15	3	5
492	Frames	" 6	" 17	3.6	0.3	11	12	3	12
495		July 27	" 18	3.2	0.25	10	5	3	4
496		Aug. 8	" 15	3.7	0.33	15	1	2	3
498		July 31	" 18	3.9	0.35				7
499	Large Purple Straw	Aug. 6	" 16	3.9	0.3	11	10	4	5
500		" 10	" 16	3.6	0.35	9	10	2	10
501		" 6	" 18	4.0	0.35	9	8	3	3
503		" 8	" 16	3.5	0.25	8	2	2	6
505		July 29	" 16	3.75	0.3	14	6	4	6
508	*America								
509	*Russian Hard								
511	*Patagonia Trigs								
512	*McCregan								
513	*Farquhar								
514	*Canadian Wonder								
515	*Bearded Monarch								
516	*Badger								
517	Andrus		Oct. 8						
518	*Big English	Aug. 19							
520	*German Emperor								
521	*Lehigh								
522	Lebanon	July 31	Sept. 15	3.75	0.3	12	13	3	12
524	*Rudy		Oct. 7	4.5	0.4				2
525	*Witter								
526	*Wyandot Red			3.15	0.23				
527	*Early Ripe								
528	*Gypsy								
529	*Golden Cross								
530	*Jones' Square Head								
531	*Johnson's								
532	*Longberry								
533	*Miller's Prolific								
534	*Roberts'								

*This is a winter variety.

TABLE I (Concluded).—*Wheat, 1896.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of straw and grain from 50 feet of row	Yield of grain from 50 feet of row
				feet	*feet*	*lbs. oz.*	*lbs.oz.*
535	*Smith's White						
537	*Wisconsin Triumph						
538	*Willets						
539	*Yuva						
541	*Odessa No. 1						
542	* " No. 2						
543	* " No. 3						
544	* " No. 4						

*This is a winter variety.

TABLE II.—*Wheat, 1897.*

This gives the results of the second year's trial of all the varieties reported in Table I which matured seed in 1896. One row 50 feet long of each variety was planted. The rows were 18 inches apart.

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of straw and grain from 50 feet of row		Yield of grain from 50 feet of row		Weight per bu.
				feet	*feet*	*lbs.*	*oz.*	*lbs.*	*oz.*	*lbs.*
1	Minnesota Fife	July 28	Sept. 28	4.06	0.29	10		2	10	62
2	White Fife	" 28	" 30	3.97	0.31	1	13		15	54.5
3	Sherman	" 22	" 22	3.81	0.25					
4	White Russian	" 20	" 22	3.59	0.25	2	3	1	6	60.5
5	Odessa	" 28	" 21	3.89	0.29	16	10	2	14	60.5
6	Eldorado	" 20	" 24	3.8	0.3	13	5	3	7	58.5
7	Soft Australian	" 28	Oct. 2	4.02	0.36	2	1	1		54
8	Defiance									
9	Champion	" 22	Sept. 23	3.62	0.39	12	12	3	1	57.5
10	Oregon Club	" 28	" 28	3.59	0.3	9	6	1	14.5	57.5
12	Sonora	" 13	Oct. 2	3.55	0.26	1	6		4	49
13	White Mexican	" 28	Sept. 30	4.25	0.29	1	9		12	52.5
14	Improved Fife									
16	Brooks	" 28	" 23	4.2	0.45	13	13	2	15	58
17	Rio Grande	" 22	" 21	3.7	0.37					
18	Canada Club	" 28	" 23	3.6	0.33	8	8	1	1	
19	Judkins	" 20	" 28	3.62	0.33	18	2	3	9	57
20	Lost Nation	" 22	" 28	3.72	0.36	11	14	3	2	59
21	Touzelle	" 20	Oct. 2	3.62	0.27	1	12		13	57.5
22	Australian Club	" 20	Sept. 23	3.6	0.29	10	3	3	4	61.5
25	China Tea	" 22	" 23	3.93	0.3	15	3	3	14	64
26	Chili	" 20	" 23	3.88	0.33	14		3	13	62
28	Egyptian	" 22	" 24	3.75	0.26	12	4	2	14	57.5
29	Saxon Fife	" 22	" 21	3.4	0.33	1	5		15	60.5
30	Dominion	" 28	" 24	3.78	0.31	9	8	2	1	55.5
31	Prussian	" 28	" 29	3.75	0.23	16	7	1	11	50

TABLE II (Continued).—*Wheat, 1897.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of straw and grain from 50 feet of row		Yield of grain from 50 feet of row		Weight per bu.
				feet	*feet*	*lbs*	*oz.*	*lbs.*	*oz.*	*lbs*
32	Golden Drop	July 22	Sept. 25			13	8	2	6	59.5
33	Pringle's No 6	" 28	" 29	4.12	0.35	15	1	1	16	51.5
34	" No. 4	" 28	" 29	4.32	0.29	18	2	2	15	53.5
35	" No. 5	" 22	" 29	3.3	0.34	18		2	15	56
38	Fultz	" 28		3.52	0.33					
40	Black Centennial									
41	Hedgerow	" 20	" 25	3.28	0.14	18	15	3	8.5	53.5
42	Granite	" 22	" 25	3.58	0.26	14	9	3	13	57.5
43	Italian									
44	New York Flint	" 22	" 28	3.9	0.3	8	9	2	9	58.5
45	Bald Baltic	" 22	" 22	4.1	0.39	12	10	3	6	61
48	Red Orange	" 22	" 21	4.0	0.37					
51	Hybrid No. 10	" 22	" 25	4.0	0.35	19	14	4	6	57.5
54	Velvet Chaff	Aug. 2		4.07	0.36	1	1		4	43
55	Turkey	July 28	Oct. 2	4.17	0.29	1	8		8	55
56	Sardonyx	Aug. 6	" 2	4.5	0.38	1	4		4	54.5
57	Amethyst									
58	Ruby	" 2	Sept. 29	3.49	0.36	1	9		12	54
59	Jasper	July 22	" 28	4.5	0.35	19	3	3	6	58
62	Emerald									
63	Black Chaff	" 28	" 23	4.0	0.35	15	13	1	14	57
64	Cretan	" 20	" 23	4.07	0.24	11	15	3	1	62
70	Anautka	" 20	" 22	3.58	0.25			2	12	63
71	Fountain	" 22	" 25	3.5	0.33	17	12	4	11	61.5
72	Palestine	" 22	" 28	3.87	0.27	15	12	3	8	59.5
73	White Chaff (smooth)	" 20	" 21	3.55	0.23	1	13	1	2	57.5
74	" " (bearded)	" 22	" 22	3.26	0.25	1	4		11	59
76	Perfection	" 28	" 28	4.27	0.28	17	7	3	6.5	56
77	German Fife	" 22	" 25	3.7	0.4	18		4	1	63
78	Mammoth	" 28	" 28	3.72	0.33	8	11	1	13	58
80	Samara	" 22	Oct. 2	3.4	0.33	1	5		15	60.5
81	Durum	" 22	Sept. 24	3.55	0.18	11	7	3	6.5	60
82	Saratov	" 20	" 21	3.4	0.3	1	9	1		61
84	Moscow	" 28	" 28	3.75	0.28	7	5	2	4.5	60.5
85	Knapp	" 20	" 28	3.62	0.28	17	6	3	5	58
87	Doty	" 20	" 24	3.68	0.31	16	8	2	14	59
89	White Michigan	" 28	" 30	4.14	0.27	1	12		14	56
90	Rickenbrode	" 28	" 21	3.4	0.3					
91	Red Siberian	" 28	" 29	4.14	0.32	1	6		12	56.5
98	German Amber	Aug. 6		3.65	0.3					
100	Dallas	July 31	" 23	4.02	0.3	14	14	2	11	58
102	Finlay	" 28		3.58	0.39					
106	Early May	" 28	" 24	3.4	0.35	2				
107	Rocky Mountain	Aug. 2	Oct. 9	3.58	0.33				4	52
110	Propoe	July 28	Sept. 29	4.3	0.31	22	14	1		54
117	Big May	Aug. 6	Oct. 9	4.15	0.3	5	10		3	47
118	Sardius	" 2	" 2	3.67	0.31	1	9		9	59.5
119	Chrysolite	July 22	Sept. 23	3.5	0.3	14	4	3	5	61.5
120	Beryl	" 28	" 24	3.59	0.26	10		2	2	58.5
122	Jacinth	" 25	" 28	3.65	0.35	10	10	2	8.5	52
123	Carnelian	" 28	" 23	3.75	0.32	12		1	13	
124	Agate	" 22	" 24	3.65	0.23	5	14	1	8	58½
125	Onyx	" 28	" 28	3.82	0.26	11	1	3	2	56
126	Opal	" 28	" 28	3.97	0.24	11	7	3	8	57
127	Garnet	" 31	" 25	4.14	0.33	18	1	3	9	59
128	Tourmaline	" 28	" 22	3.69	0.18	1	9	1	1	61
131	Casaca	" 31	" 23	4.15	0.33	16	4	2	2.5	

TABLE II (Continued).— *Wheat, 1897.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of straw and grain from 50 feet of row		Yield of grain from 50 feet of row		Weight per bu.
				feet	*feet*	*lbs.*	*oz.*	*lbs.*	*oz.*	*lbs.*
133	Tuscan	July 28	Oct. 2	4.6	0.32	1	15		6	55
135	Tuskana			3.36	0.39					
136	Pearl		" 9	4.01	0.29	9	3		11	51
138	White Chaff	" 20	Sept. 30	3.81	0 31	1	13	1		52.5
145	Red Oregon Club	" 28	" 29	3.82	0.29	1	7		9	52.5
146	Hedgerow	" 28	" 25	3.75	0.18	15	8	1	13	
147	Aowse	" 22	" 22	3.82	0.33	13	14	3	14	50.5
148	Monmouth	" 28	" 28	3.88	0.29	11	2	2	7	63.5
149	Russian (spring)	" 20	" 21	4.5	0.37	2	2	1	6	53
150	Vermillion	" 28	" 30	4.07	0.36	2	2			54
151	Smoky	" 28	" 22	4.0	0.3	1	4		12	63.5
152	Edenton Fife									
153	Nox No. 2	" 28	" 28	4.06	0.36	10	6	3	7	50.5
154	" No. 1	" 28	" 28	3.93	0.33	11	4	2	4	60
156	" No. 3	" 22	" 28	3.52	0.32	2	4	1	8	50
157	" No. 5	" 22	" 28	3.72	0.37	11	6	2	14	58
158	Pringle's No. 17	" 28	" 29	4.3	0.34	21	10	3	7.5	52.5
160	Wales	" 28	" 30	4.34	0.33	1			5	54
162	Northcote's White	" 22	" 28	3.46	0.28	5	13	1	10	62
165	Cut Mountain	" 28	" 24	4.1	0.36	8	12	1	3	55.5
166	Red Straw	" 28	Oct. 9	3.52	0.29					
167	Cayaga	" 22	Sept. 23	3.92	0.33	9	2	1	11.5	
168	Black Chaff	" 31	" 23	3.98	0.36	18	1	2	3	59.5
169	Gneiss	" 28	" 25	3.5	0.33	19	4	4	6	58.5
170	Velvet Amber	Aug. 6	Oct. 2	4.4	0.34	1	10		7	54.5
171	Hebron		" 30	3.36	0.36	1	4		7	53
172	Quartz	July 25	Sept. 20	3.65	0.3	1	5		10	52
173	White Mediterranean			3.36	0.26					
174	Red "	" 28	" 29	3.52	0.33					
176	Nebraska	" 20	" 28	3.1	0.3	5		1	1	
177	White's	" 26	" 21	3.94	0.28	1	8		10	57
178	Kivet			4.33	0.39					
179	Rust Proof									
180	Baltimore	" 31	Oct. 9	4.2	0.26	8			3	
182	Purple Straw	" 31	Sept. 29	4.2	0.26	21	4	2	5	51.5
184½		" 28	" 30	4.04	0.33					
186	Wintergreen	Aug. 9		4.11	0.36					
189	Hunter's Spring			3.68	0.36					
192	Geiger	July 20	" 25	3.0	0.28	12	4	3	8	60
193	Hornblende	" 22	" 25	3.52	0.27	17	11	3	12	57.5
195	Edmenton	" 22	" 24	3.26	0.33	13	4	3		61
196	Winnipeg Russian	" 28	" 30	3.91	0.29	1	13		11	54
197	Rust Proof		" 21	3.5	0.3	1	6		13	60
198	Winnipeg	" 28	" 30	4.66	0.29	2	2	1		59
200	Hallett's Pedigree	" 28	" 25	3.78	0.32	17	8	3	8	58
201	Sibley's No. 1	" 22	Oct. 2	4.63	0.24	1	14		5	53
202	French Black Chaff	" 28		3.58	0.33					
203	Rural	" 20	Sept. 29	4.23	0.25	1	7		10	57
204	Velvet Club	Aug. 2		4.76	0.33					
207	Whittington	July 28	" 30	4.4	0.29	1	10		11	53.5
208	Snowflake	" 28	Oct. 2	4.4	0.35	1	12	1		55
210	Tagarog									
213	China Red	" 22	" 9	4.24	0.33	8			15	58
214	Missouri Turkey	Aug. 2	" 9	3.82	0.33	11		1	7	55
216	California Walker	July 28	Sept. 23	3.8	0.35	4	1		4.5	57
219	Andrus Black									
222	Saskatchewan	" 26	Oct. 2	3.91	0.33	1	7		12	58

TABLE II (Continued).—*Wheat, 1897.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of straw and grain from 50 feet of row		Yield of grain from 50 feet of row		Weight per bu.
				feet	*feet*	*lbs.*	*oz.*	*lbs.*	*oz.*	*lbs.*
223	Rye		Sept. 29	4.46	0.31	1	13		13	56
224	Frankenstein	July 22	" 25	3.35	0.33	12	3	2	10.5	62
225	March	" 20	" 28	3.42	0.26	7	17	2	10	62.5
226	Flanders			3.42	0.36					
227	Flourelle	Aug. 6		3.72	0.33					
229	Circassian	July 28	Oct. 9	3.91	0.33	6			2	
230	White Velvet	" 28	Sept. 30	4.01	0.27	2		1		53
231	Verplank			3.91	0.39					
234	Wicker	" 28	" 30	3.81	0.23	2		1	2	52.5
235	Hopetown			3.36	0.36					
236	Talavera	" 20	" 21	4.0	0.4					
238	Shumaker	" 22	Oct. 2	4.21	0.33	1	11		15	58
240	Snake River	" 28	" 2	4.07	0.35	1	12	1		57.5
241	Red River	" 20	Sept. 29	3.49	0.29	1	11		11	48.5
242	Upland	" 28	Oct. 2	4.27	0.29	1	10		14	54
243	Hard Manitoba	" 28	Sept. 26	3.91	0.31	18	9	3	3	57.5
244	Santa Fe	" 28	" 29	4.17	0.29	2	1	1	1	56.5
252	Armstrong									
255	Tasmanian Red	Aug. 18		4.08	0.48					
257	Treadwell	July 28		4.72	0.39					
259	Arnold's Hybrid									
266	Michigan Wick									
268	Powers	" 22		3.36	0.3					
280	Uxbridge	" 31	Oct. 2	4.2	0.29	1	8		13	52
283	Rust Proof (soft)	Aug. 22	Sept. 21	3.5	0.33	1	14	1	3	61.5
288	Dand Khan No. 2	July 20	" 23	2.6	0.26	8	12	2	12	63
290	Niagara	" 22	" 28	4.0	0.4	9	4	2	2	61.5
292	Fulcaster	" 31		3.48	0.26					
299	Tappahannock	Aug. 6		4.24	0.37					
301	Basalt	July 28	Oct. 9	4.1	0.36	7	6	1		51.5
302	Flourspar	" 28	Sept. 25	3.4	0.3	15	14	4	3	61
303	Granite	" 22	" 25	3.55	0.29	16	4	4	10	57.5
304	Platinum	" 28	" 29	4.07	0.29	15	9	2	10	50.5
305	Porcelain	" 28	" 21	4.4	0.31	17	6	2	14	57.5
306	Silica	" 22	" 22	3.85	0.33	1	9		11	61.5
307	Trap	" 28	Oct. 2	4.05	0.3	1	8		10	53
309	Pool's Red	" 28	Sept. 29	4.14	0.31	17	7	2	14	55
319	Deitz Red	" 28	" 24	3.56	0.32	14	2	2	3.5	58.5
321	" Amder	Aug. 6		3.72	0.27					
331	Weeks	July 28	" 30	4.21	0.29	2	3	1	2	54
332	Hoover		" 25	3.7	0.33	15	8	2	13	
334	Valley	Aug. 9		3.57	0.44					
336	Early Oakley	July 28	" 24	3.5	0 3	15	5	5	8.5	57
337	Genoese									
342	Indian	" 22	" 28	3.75	0.38	14	8	3		60
344	Baart	" 20	" 24	3.7	0.29	11	8	3	8	59
347	Ward's Prolific	" 20	" 30	4.34	0.43	2	4	1	4	59
348	Roseworthy		" 21	2.0	0.22					
349	Australian Purple Straw	" 22	" 22	3.8	0.25	13	8	3	10	61.5
355	Du Toits	" 20	" 24	3 26	0.26	12	10	3	4	59
358	Rattling Tom	" 22	" 29	4.0	0.33	1	11		10	53
359	Volo	" 20	" 30	4.14	0.21	2	2		13	54.5
360	Missogen	" 20	" 28	3.68	0.32	8	6	2	14.5	61.5
361	Atlanti	" 22	" 24	3.81	0.21	9	11	2	9	57
363	Sadoza									
364	Curtis' White	" 22	" 23	3.98	0.39	11	7	2	10.5	59
365	Seven Headed Red	" 22	Oct. 2	4.11	0.31	2		1	4	58

TABLE II (Continued).—*Wheat, 1897.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of straw and grain from 50 feet of row		Yield of grain from 50 feet of row		Weight per bu.
				feet	*feet*	*lbs.*	*oz.*	*lbs.*	*oz.*	*lbs.*
366½	. . . .	July 20	Sept. 30	3.78	0.2	1	12	1		53
389	Carter's B			5.26	0.26					
306	" I	July 31	Sept. 23	4.0	0.35	17	4	1	8	
397	" J	Aug. 2	Oct. 9	3.81	0.42	4			5	
398½	. . . .			3.78	0.33					
400	Algerian No. 1	July 28	Sept. 24			9	9	1	4	61
401	" No. 2	" 20	" 22	3.08	0.22	6	4	2	0	
401½	. . . .	" 22	" 30	3.30	0.2	2	2	1	1	58
402	" No. 3	" 31	Oct. 9	3.78	0.35	4			2	49
402½	. . . .	Aug. 6	" 9	4.24	0.33					
403	Reiti			3.59	0.42					
405	Zeland	July 31	Sept. 30	4.44	0.37	1	3		8	55
406	Lanneurde Mars	" 28	" 28	3.75	0.33	11	4	1	12	56
409	Mold's Red	" 28	" 28	4.0	0.3	8	8	2	1	60.5
411	Hungarian	" 28	" 25	3.88	0.35	15	7	1	7	55.5
412	Prize	" 22	" 29	3.45	0.26	17	6	4	9	55.5
413	Little Wonder	" 22	" 28	3.49	0.21	12	15	4	2	58.5
414	Champion	" 22	" 23	3.62	0.25	10	4	1	10	
416	Oakshot's Champion	" 22	" 28	3.85	0.28	11	12	2	13	60.5
419	McDowell	" 22	" 28	3.69	0.29	12	10	3	4	62
420	Young's	" 20	" 21	3.75	0.23	2	4	1	7	58.5
421	California Red	" 20	" 23	2.65	0.29	9	11	2	2	57
422	Little Club	" 22	" 28	3.7	0.2	8	11	2	8	53.5
425	Purple									
426	Tuscan	" 28	Oct. 2	4.46	0.29	1	12		14	55
427	Jubilee	" 20	Sept. 28	3.88	0.3	10	6	1	11	48.5
428	Leake's	" 28	" 28	3.55	0.25	10	14	3	2	61.5
431	Rodi	" 20	" 29	2.9	0.27	1	11		9	50
431½	. . . .	" 20	" 21	2.45	0.26					
432	Dera									
433	Baggi	" 20	" 22	2.53	0.23	9	2	3	4	65
434	Ratti	" 20	" 29	3.26	0.24	1			4	52
435	Dorin	" 20	" 28	2.96	0.18	9	8	2	5	56.5
437	Walu	" 13	" 30	3.68	0.23					51
438	Lohi	" 20	" 28	3.35	0.21	6	13	2	2	57
439	Khel	" 23	" 30	3.5	0.22	1	4		7	51
440	Shega	" 20	" 22	3.26	0.26		13		7	57
441	Awal No. 1	" 20	" 28	3.39	0.21	9	11	2	11	55.5
442	" No. 2	" 20	" 28	3.16	0.26	10	13	8	13	53.5
444	Archer's Prolific	" 20	" 22	3.2	0.25	9	9	2	15	60.5
446	Daub I	" 25	" 23	3.98	0.29	10	12	2	3	
447	Farrie's Durum									
448	Barwick	" 22	" 23	3.5	0.33	14	2	2	12	54
449½	Samara Club	Aug. 13	Oct. 2	4.24	0.3		10		3	54
450	Bancroft	July 20	Sept. 22	3.15	0.2	6	12	2	2	56.5
452	Banater	" 28	" 24	3.85	0.24	9	14	3	8	58
453	Paros	" 22	" 28	4.04	0.24	12	8	3	3	57
454	Cape	" 20	" 23	3.33	0.27	15	1	4	3	59
456	Hudson's									
457	Murray River	" 28	" 28	3.3	0.33	4	8		8	
458	Green Mountain	" 22	" 25	3.62	0.31	15	9	3	8	55.5
460	Cordova	" 22	" 23	3.8	0.37	10	8	1	8	
461	Little Club	" 20	" 28	3.08	0.13	11	3	2	12	58
463	Carter's I	Aug. 2	" 23	4.0	0.42	15	14	1	15	56
464	Laird's Prolific	July 28	" 28	3.88	0.27	13	12	3	8	56.5
465	Borneo	" 20	" 23	3.9	0.3	12	8	3	3	57.5
467	Veneta			4.42	0.45					

TABLE II (Continued).—*Wheat, 1897.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of straw and grain from 50 feet of row		Yield of grain from 50 feet of row		Weight per bu.
				feet	*feet*	*lbs.*	*oz.*	*lbs.*	*oz.*	*lbs.*
468	Varlsotta.	July 31	Oct. 2	4.4	0.39		7			48
470	Belolourka.	" 28	Sept. 24	4.3	0.23	11	6	2	9.5	53.5
471	Reiti 2.	Aug. 2	Oct. 9	4.2	0.37	1-	3		4	55
472	Bordeaux	" 2	Sept. 24	4.3	0.3	14	7	1	4	53
478½	Gypsum Fleck	July 20	" 25	4.24	0.37	21	10	2	2	52
481	Northern Champion . .	" 22	" 28	3.7	0.28	6	12	1	10	
483	. . . .	" 22	Oct. 2	3.7	0.27					
484	. . . .	" 22	Sept. 25	3.85	0.33	14	15	4	0	58.5
485	. . . .	" 20	" 24	3.62	0.09	14	11	2	8	57
492	Frames	" 22	" 25	3.26	0.3	12	15	3	4	60
495	. . . .	" 22	" 25	3.88	0.29				6	53
498	. . . .	" 28	Oct. 2	4.24	0.33				5	59
499	Large Purple Straw . .	" 22	Sept 28	3.29	0.24	8	12	3	10	60 5
500	. . . .	" 20	" 28	3.58	0.33	16	8	3	8	58
501	. . . .	" 22	" 30	4.4	0.36	1	2			56
503	. . . .	" 28	" 28	3.81	0.31	13	6	2	4	57.5
505	. . . .	" 22	" 29	3.78	0.31	1	6		10	53.5
525	Purple.	" 28	" 20	3.26	0.26	21	4	2	8	
526	Wyandot.	Aug. 9	Oct 9	3.91	0.31				2	54
540	. . . .	July 28	Sept. 28	4.14	0.33					59
543	Odessa No. 3.			3.94	0.37					
544	" No. 4.			3.0	0.39					

TABLE III.—*Wheat, 1898.*

This gives the results of the first year's trial of Professor Blount's collection of wheats. The varieties reported on in Tables I and II were originally from Professor Blount, but the varieties reported in the following table were grown from seed selected by him personally and furnished gratis to the Station. One row ten feet long of each variety was planted. The rows were 20 inches apart.

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of grain from 10 feet of row	Weight per bu.
				feet	*feet*	*oz.*	*lbs.*
1	Minnesota Fife	July 19	Aug. 29	3.4	0.36	12	60
2	White Fife	“ 23	Sept. 9	2.96	0.33	8	57.5
3	Sherman	“ 14	Aug. 27	2.84	0.15	16	63
4	White Russian	“ 14	“ 27	3.1	0.36	14	63.5
5	Odessa	“ 14	Sept. 9	3.65	0.33	5	58
6	Eldorado	“ 12	“ 6	3.29	0.27		
7	Soft Australian	“ 14	“ 2	3.0	0.35	10	60
8	Defiance	“ 14	“ 2	3.55	0.36	15	59.5
9	Champion	“ 14	“ 2	3.26	0.36	14	60
10	Oregon Club	“ 14	“ 6	3.29	0.33	5.5	52
11	Hard Australian	“ 19	“ 6	3.85	0.38	8	51.5
12	Sonora	“ 12	“ 2	2.67	0.6	8	61.5
13	White Mexican	“ 12	“ 6	3.3	0.35	12	57.5
14	Improved Fife	“ 19	“ 6	3.26	0.39	8	57
15	Russian	“ 19	“ 2	3.14	0.39	8.5	57.5
16	Brooks	“ 19	“ 9	3.2	0.47	7	54
17	Rio Grande	“ 14	Aug. 28	3.34	9.4	16	63
18	Canada Club	“ 19	Sept. 2	2.84	0.3	14	62
19	Judkin	“ 19	“ 9	2.96	0.43	8	57
20	Lost Nation	“ 19	“ 6	3.29	0.34	6	54
21	Touzelle	“ 12	Aug. 27	2.9	0.27	9	63
22	Australian Club	“ 14	“ 29	2.67	0.3	11	58.5
23	Golden Globe	“ 23	Sept. 9	3.1	0.41	11	60
24	Mediterranean Spring	“ 23	“ 9			9	58
25	China Tea	“ 19	“ 3	3.2	0.46	9	62
26	Chili	“ 12	“ 3	2.37	0.33	11	50
27	China Spring	“ 19	“ 9	3.28	0.41	7	52.5
28	Egyptian	“ 12	“ 6	3.39	0.3	6	60
29	Saxon Fife	“ 23	“ 9	3.0	0.36	8	56.5
30	Dominion	“ 23	“ 3	3.1	0.33	10	50
31	Prussian	“ 19	“ 3	2.87	0.27	9	61
32	Golden Drop	“ 19	“ 3	2.67	0.25	11	61.5
33	Pringle's No. 6	“ 19	“ 6	3.0	0.33	6.5	50
34	“ No. 4	“ 23	“ 9	3.16	0.35	6	54
35	“ No. 5	“ 19	“ 6	3.1	0.33	7.7	56
36	Winter Australian	“ 23	“ 6	3.23	0.36	7.5	52.5
38	Fultz	“ 19	“ 9	2.96	0.35		
39	Midge Proof	“ 23	“ 6	2.81	0.3	6	48
40	Black Centennial	“ 19	“ 6	2.74	0.32	9	56
41	Hedgerow	“ 19	Aug. 31	2.55	0.16	12	60.5
42	Granite	“ 19	Sept. 6	2.87	0.34	9.5	58
43	Italian	“ 12	“ 6	3.13	0.74	11	62.5
44	New York Flint	“ 19	“ 6	2.9	0.32	4	53.5
45	Bald Baltic	“ 19	“ 6	2.7	0.35	6.5	57
47	Illinois Second Premium	Aug. 12	“ 12	3.2	0.35		
48	Red Orange	July 19	Aug. 29	3.2	0.39	13	60
50	Perkey	“ 12	“ 29	2.96	0.23	9	62
51	Hybrid No. 10	“ 23	Sept. 9	2.67	0.34	9	57
52	Golden Chaff	“ 14	Aug. 29	3.0	0.34	12	59
53	Mediterranean Red Chaff	“ 23	Sept. 6	2.97	0.3	8	58
54	Velvet Chaff	“ 23	“ 9	3.2	0.39	8	54.5
55	Turkey	“ 19	“ 6	2.87	0.27	5.5	56

*This is a winter variety.

TABLE III (Continued).—*Wheat, 1898.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of grain from 10 feet of row	Weight per bu.
				feet	*feet*	*oz.*	*lbs.*
56	Sardonyx	July 28	Sept. 6	2.9	0.33	7.5	58
57	Amethyst	" 23	" 6	3.16	0.33	8.5	58
58	Ruby	" 28	" 9	2.8	0.36	7	54
59	Jasper	" 19	" 6	3.2	0.39	10	57.5
60	Sapphire	" 19	" 6	2.9	0.41	8.5	53.5
61	Chalcedony	" 19	" 6	2.94	0.3	12	52
62	Emerald	" 19	" 6	3.26	0.46	4	54
63	Black Chaff	" 23	" 9	2.94	0.36	6	58
64	Cretan	" 15	Aug. 29	3.2	0.26	8	63
65	Andriola Red	" 19	" 31	2.66	0.33	8	62.5
66	" Amber	" 19	" 29			11	62.5
67	Purple Chaff	" 14	Sept. 6	2.9	0.18	11	60
68	Boughton	" 19	" 9	3.13	0.18	11	59.5
70	Anautka	" 12	Aug. 29	3.6	0.2	12	65
71	Fountain	" 19	" 26	3.0	0.3	10	55.5
72	Palestine	" 23	Sept. 6	3.35	0.43	9	56.5
73	White Chaff (smooth)	" 23	" 6	2.85	0.26	13	59
74	" " (bearded)	Never came	up				
76	Perfection	" 19	" 9	2.83	0.35	13	56.5
77	German Fife	" 19	" 6	3.26	0.36	9.5	58
78	Mammoth	" 23	" 9	3.16	0.33	7	52
79	*Triticum	Aug. 31					
80	Samara	July 19	" 9	3.43	0.24	8	59
81	Durum	" 19	" 9	3.43	0.24	5	59
82	Saratov	" 23	" 9	2.96	0.35	6	56
83	Ames	" 19	" 9	3.43	0.24	9	61
84	Moscow	" 23	" 9	2.96	0.35	5	60
85	Knapp	" 19	" 9	2.96	0.35	9	59
86	Scotch Fife	" 23	" 9	3.13	0.35	8	56.5
87	Doty	" 14	Aug. 29	2.88	0.86	12	63
88	Meekins	" 14	Sept. 6	3.36	0.41	4	63
89	White Michigan	" 28	" 9	3.03	0.33	4	57
90	Rickenbrode	" 23	" 9	3.39	0.32	8	54.5
91	Red Siberian	" 19	" 9	3.29	0.35	9	54.5
92	*Heige's Prolific						
94	*Rice						
96	*Gold Medal						
97	*Glass						
98	*German Amber	Aug. 12					
99	*Wysor	" 23					
100	Dallas	July 23	" 6	3.2	0.34	11	58.5
101	*Champion Amber	Aug. 12					
102	Finlay	" 12	" 15	3.33	0.35	5	45
103	*Lemon						
104	*McGee's Red	" 4					
105	*Bennet	" 12					
106	*Early May	" 30					
107	*Rocky Mountain	" 4					
108	*Silver Chaff	" 23					
109	*Blue Stem						
110	Propoe	July 19	Oct. 29	2.7	0.3	17.5	59.5
111	*Small Frame	Aug. 23					
112	Red Clawson	July 28	Sept. 15	3.03	0.33	3	59
113	*Yellow Missouri						
114	*Walker						

*This is a winter variety

TABLE III (Continued).— *Wheat, 1898.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of grain from 10 feet of row	Weight per bu.
				feet	*feet*	*oz.*	*lbs.*
116	*Zimmerman						
117	Big May	July 19	Sept. 12	3.52	0.33	8	54.5
118	Sardius	" 19	" 6	3.58	0.35	11.5	60
119	Chrysolite	" 14	Aug. 31	3.0	0.35	17.5	58
120	Beryl	" 14	" 31	3.03	0.3	12.5	59.5
121	*Topaz	" 14					
122	Jacinth	" 14	" 29	3.2	0.3	16	60
123	Carnelian	" 19	Sept. 6	2.87	0.29	9	53.5
124	Agate	" 19	" 6	2.87	0.29	9	56
125	Onyx	" 14	" 6	2.87	0.29	13	54
126	Opal	" 19	" 6	2.87	0.29		
127	Garnet	" 19	" 7	3.0	0.36	6	57
128	Tourmaline	" 23	" 7	2.83	0.22	8	59
129	Felspar	" 19	" 7	2.83	0.34	9	51.5
131	Casaca	" 28	" 10	3.1	0.4	6	56
133	Tuscan	" 19	" 7	3.32	0.34	7	57.5
134	*Essex	Aug. 12					
135	Tuskana	" 12	" 15	3.33	0.31	3	42
136	*Pearl	" 4					
137	*Hunter's Winter	" 23					
138	White Chaff	July 19	" 7	2.94	0.31	11	55.5
140	*Gold Drop	Aug. 30					
145	Red Orange Club	July 23	" 12	2.84	0.28	8	52
146	Hedgerow	" 28	" 12	2.74	0.14	8	53.5
147	Aowse	" 28	" 7	3.39	0.32	15	53.5
148	Monmouth	" 19	" 7	3.26	0.4	8	58
149	Russian (Spring)	" 23	" 7	3.0	0.4	7	56.5
150	Vermillion	" 23	" 7	3.26	0.42	7	56
151	*Smoky	" 23					
152	Edenton Fife	" 23	" 7	3.26	0.33	6	50
153	Nox No. 2	" 19	" 12	3.2	0.35	9	50
154	" No. 1	" 23	" 10	3.26	0.37	9	55.5
155	" No. 4	" 19	" 7	3.26	0.42	8	57
157	" No. 5	" 19	" 10	3.29	0.41	12	54.5
158	Pringle's No. 17	" 19	" 10	3.03	0.36	8	54
159	" No. 18	" 23	" 10	3.2	0.39	8	51
160	Wales	" 19	" 10	2.9	0.36	9	56
161	Dead Sea	Aug. 12	" 15	2.8	0.3	0.5	42
162	Northcote's White	July 23	" 10	3.03	0.35	11	54
163	" Amber	" 19	" 7	3.0	0.35	8	53.5
164	White May	" 14	" 7	2.8	0.33	11	59
165	Cat Mountain	" 23	" 15	3.1	0.36	2	52.5
166	Reed Straw	Aug. 4	" 15	3.29	0.33	3	54
167	Cayaga	July 19	" 7	3.4	0.4	12.5	59.5
168	Black Chaff	" 28	" 12	3.2	0.4	7	56
169	Gneiss	" 23	" 12	3.2	0.3	12	50
170	*Velvet Amber	Aug. 12					
171	Hebron	July 28	" 15	4.88	0.26		
172	Quartz	" 12	" 10	2.96	0.36	12	59.5
173	*White Mediterranean	Aug. 17	" 19	3.72	0.38		
174	Red "	July 19	" 12	3.39	0.28	4	53
175	French Imperial	" 28	" 17	4.18	0.35	8	48.5
176	Nebraska	" 12	Aug. 29	3.3	0.29	15	62
177	White's	" 19	Sept. 7	3.58	0.35	10.5	60
178	*Kivet	" 28	" 15	3.7	0.55	2	45

*This is a winter variety.

TABLE III (Continued).—*Wheat, 1898.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of grain from 10 feet of row	Weight per bu.
				feet	*feet*	*oz.*	*lbs.*
179	Rust Proof	July 19	Sept. 10	3.52	0.32	15	59.5
180	*Baltimore	Aug. 4					
181	*Davis						
182	Purple Straw	July 19	" 7	3.1	0.27	8	60
183	*Gold Premium	Aug. 17					
184	*Hick's Prolific	" 4					
185	*Earnhardt	" 17					
186	*Wintergreen	" 4					
187	*St. Ledger	" 12					
188*a*		July 19	" 7	3.26	0.35	13	58
188*b*		" 12	Aug. 29	3.0	0.33	16	60
188*c*		" 12	Sept. 7	3.0	0.30		
189	Hunter's Spring	Aug. 4	" 19	3.58	0.36	2	48
190	*Oakchott's	" 27					
191	Hardwick	July 12	Aug. 31	3.05	0.35	19	62.5
192	Geiger	" 12	" 29	3.1	0.33	11	62
193	Hornblende	" 14	Sept. 7	3.26	0.36	13	59
194	Sea Island	" 19	" 12	3.45	0.4	6	63
195	Edmenton	" 19	" 7	3.59	0.42	12	59
196	Winnipeg Russian	" 19	" 7	3.4	0.35	13.3	57.5
197	Manitoba	" 23	" 13	3.29	0.36	12	60
198	Winnipeg	" 12	" 10	3.45	0.25	12	61
199	Russian White	" 19	" 7	3.26	0.35	10	58
200	Hallett's Pedigree	" 23	" 13	3.29	0.68	7	53
201	Sibley's No. 1	" 19	" 10	3.88	0.27	10	55
202	*French Black Chaff	Aug 12					
203	Rural	July 19	" 10	3.88	0.27	7	52
204	*Velvet Club	Aug. 17					
205	Austrian	July 19	" 10	3.03	0.3	12	56
206	Bohemian	" 28	" 20	3.68	0.28	3	49
207	Whittington	" 19	" 7	2.94	0.3	9	56.5
208	Snowflake	" 19	" 10	3.23	0.32	8	55
209	Beardless Velvet	" 19	" 10	2.96	0.3	12	52
210	Tagarog	" 19	" 10	3.1	0.31	9	61
211	*Michigan Amber	Aug. 23					
212	China White	July 14	Aug. 29	2.85	0.26	11	59.5
213	" Red	" 12	" 29	2.7	0.27	8.5	61
214	Missouri Turkey	" 28	Sept. 20	3.26	0.31	6	58
215	* " Mediterranean	Aug. 4					
216	California Walker	" 4	" 20	3.35	0.31	4	59
218	*India Red	" 23					
219	Andrus Black	July 19	" 13	3.26	0.32		
220	*Mediterranean Hybrid						
221	*Andrus Flint						
222	Saskatchewan	" 19	" 7	3.58	0.3	11	58
223	Rye	" 23	" 7	4.1	0.33	12	56.5
224	Frankenstein	" 23	" 10	3.30	0.32	10	56
225	March	" 14	" 7	3.26	0.3	12	58
226	Flanders	Aug. 4	" 20	3.75	0.33	2	44
227	*Flourelle	" 4					
228	Victoria	July 19	Sept. 13	3.2	0.38	5	52
229	*Circassian	Aug. 4					
230	White Velvet	July 14	" 7	3.2	0.28	16	55
231	Verplank	Aug. 4	" 19	3.43	0.35	2	48
232	*Fenton	" 4					

*This is a winter variety.

TABLE III (Continued).—*Wheat, 1898.*

No.	NAME.	Date headed	Date ripe	Height	Length of heads	Yield of grain from 10 feet of row	Weight per bu.
				feet	*feet*	*oz.*	*lbs.*
233	Sandomirk	July 14	Sept. 10	3.43	0.24	14	64
234	Wicker	" 19	" 10	3.26	0.3	1	53.5
235	Hopetown	Aug. 4	" 20	3.58	0.32		
238	Shumaker	July 14	" 7	3.7	0.4	8	58
240	Snake River	" 23	" 12	3.43	0.35	7	56
241	Red River	" 14	" 7	3.1	0.33	12	59
242	Upland	" 23	" 12	3.2	0.35	8	55
243	Hard Manitoba	" 23	" 12	3.2	0.35	4	53
244	Santa Fe	" 19	" 12	3.48	0.3	12	52.5
247	Ostery	" 23	" 13	3.16	0.35		
250	*Buckeye	Aug. 27					
251	*Nigger	" 4					
252	*Armstrong	" 17					
253	*Landreth						
254	*Red May	" 14					
255	*Tasmanian Red	" 12					
256	*Wild Goose	" 23					
257	*Treadwell	" 23					
259	*Arnold's Hybrid	" 23					
260	*Boyer	" 17					
261	*Canadian Express	" 12					
272	*Scott	" 12					
275	*White Rose	" 12					
276	*Menomite	" 12					
277	*Soule's	" 23					
278	*Hungarian	" 12					
280	Uxbridge	July 23	" 8	3.26	0.3		
283	Rust Proof (soft)	" 23	" 8	3.26	0.33	8	56
288	Dand Khan No. 2	" 5	Aug. 29	2.9	0.38	11	64
290	Niagara	" 19	Sept. 8	3.26	0.36	6	53
291	*White Mountains						
292	*Fulcaster	Aug. 4					
293	*German Emperor	" 23					
294	*Raub's Prolific	" 27					
297	*Crete	" 23					
299	*Tappahannock	" 4					
300	Gypsum	July 23	" 12	3.33	0.34	13	55.5
301	Basalt	" 28	" 8	3.91	0.36	9	55
302	Flourspar	" 23	" 8	3.72	0.35	13	56.5
303	Granite	" 23	" 8	3.39	0.33	14	57.5
304	Platinum	" 23	" 8	3.58	0.35	10	56
305	Porcelain	" 23	" 8	3.45	0.4	16	56
306	Silica	" 19	" 8	3.4	0.33	19	58.5
307	Trap	" 23	" 8	3.52	0.28	12	57.5
309	Pool's Red	" 23	" 8	3.46	0.35	15	57
310	*Early Rice	Aug. 23					
319	Deitz Red	July 23	" 12	3.33	0.31	8	55
321	" Amber	Aug. 4	" 20	3.72	0.3	1	46
322	Dayton	July 23	" 15	3.39	0.33	4	54
323	Rochester	" 28	" 12	3.9	0.33	8	53
328	*Gold Dust	Aug. 23					
330	*Jennings						
331	Weeks	July 19	" 8	3.2	0.3	16	58
332	Hoover	" 23	" 8	3.58	0.35	9	57.5
333	*	Aug. 23					

*This is a winter variety.

TABLE III (Continued).—*Wheat, 1898.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of grain from 10 feet of row	Weight per bu.
				feet	*feet*	*oz*	*lbs.*
334	*Valley	Aug. 12					
336	Early Oakley	July 23	Sept. 12	3.58	0.35	8	57.5
337	Genoese	" 23	" 8	3.28	0.33	13	57.5
339	*Egyptian Flint						
341	*Martin's Amber						
342	Indian	" 19		3.26	0.36	12	60
343	Sheriff (four-rowed)	" 12	Aug. 29	2.8	0.26	15	64.5
344	Baart		Sept. 8	3.28	0.33	14	59.5
347	Ward's Prolific	" 19	" 8	3.26	0.4	10	60.5
348	Roseworthy	" 5	Aug. 29	2.2	0.27	12	62.5
349	Australian Purple Straw	" 14	Sept. 8	3.58	0.33	19	57.5
350	" Indian	" 2	Aug. 29	2.0	0.25	14	63
354	*Sibley's Golden	Aug. 23					
355	Du Toits	July 12	Sept. 8	3.26	0.33	18	58.5
357	Steinwedel's Early	" 14	" 8	3.26	0.28	13	58
358	Rattling Tom	" 14	" 8	3.45	0.3	11	57
359	Volo	" 12	" 8	3.57	0.2	14	60.5
360	Missogen	" 23	" 12	3.52	0.39	7	50.3
361	Atlanti	" 12	" 8	3.39	0.2		
362	*Reliable	Aug. 4					
363	Sadoza	July 19	" 8	3.28	0.33	6	54
364	Curtis' White	" 19	" 8	3.46	0.38	10	56
365	Seven Headed Red	" 19	" 8	3.75	0.27	10	54.5
366	Ontario	" 12	" 8	3.2	0.18	12	60
366½		" 12	" 8	3.28	0.23	11	59.5
367	*Improved Rice	Aug. 4					
368	*Currat's Prolific						
369	*Mealy	" 23					
370	*Egyptian No. 1	" 17					
383	" F	July 19	" 8	3.58	0.33	8	55.5
386	*Pollard						
388	*Carter's A	Aug. 17					
389	" B	" 12	" 20	3.85	0.22	2	38
390	* " C	" 17					
391	* " D	" 12					
392	* " E	" 17					
393	" F	" 4	" 15	3.35	0.39	2	42
394	* " G	" 12					
395	* " H	" 12					
397	* " J	" 23					
398	" K	" 17	" 20	3.65	0.26	1	36
398½		" 12	" 20	3.11	0.31	3	40
399	*Northcote's Amber	" 27					
400	Algerian No. 1	July 12	" 8	3.28	0.23	24	60.5
401	" No. 2	" 12	" 8	3.26	0.23	22	62.5
401½		" 12	" 8	3.28	0.21	19	62
402	" No. 3	" 12	" 8	3.58	0.28	12	60.5
402½		" 28	" 15	4.24	0.3	6	49
403	*Reiti	Aug. 12					
404	Galland Hybrid	" 4	" 15	4.24	0.3	2	45
405	Zeland	July 23	" 12	3.91	0.39	11	57
406	Lanneurde Mars	" 19	" 8	3.5	0.33	8	56
407	Berthoud	" 28	" 5	4.24	0.3	9	51.5
408	Mold's White	Aug. 12	" 15	3.52	0.33	1	40
409	* " Red	" 27					

*This is a winter variety.

TABLE III (Continued).—*Wheat, 1898.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of grain from 10 feet of row	Weight per bu.
				feet	*feet*	*oz.*	*lbs.*
409½	*	Aug. 23					
410	Algerian White.	July 28	Sept. 15	4.88	0.26		
410½	. . . .	" 14	" 8	2.9	0.26	8	55
411	Hungarian.	Aug. 4	" 15	3.52	0.32	2	41
412	Prize	July 5	" 8	3.8	0.25	14	56.5
413	Little Wonder.	" 19	" 8	3.26	0.28	13	55
414	Champion.	" 19	" 12	3.65	0.33	13	52
416	Oakshot's Champion. . . .	" 12	" 8	3.26	0.3	14	59.5
417	*Incomparable						
418	Fillbag	" 5	Aug. 29	2.6	0.24	17	64
419	McDowell.	" 19	Sept. 8	3.58	0.33	9	56.5
420	Young's.	" 12	" 8	3.5	0.33	22	57
421	California Red	" 5	" 8	3.0	0.28	11	60.5
422	Little Club	" 19	" 12	3.2	0.2	9	50
423	*Dookie.	Aug. 23					
424	Essex	July 19	" 12	3.39	0.35	16	54
425	Purple	" 19	" 8	3.42	0.33	10	54.5
426	Tuscan	" 14	" 8	3.26	0.36	16	58
427	Jubilee	" 12		3.2	0.37	14	63
428	Leake's	" 19	" 8	3.26	0.3	10	59
431	Rodi	" 5	Aug. 29	2.4	0.28	13	65
431½	. . . .	" 5	Sept. 8	2.61	0.3·	11	61
431⅓	. . . .	" 12	Aug. 31	2.71	0.33	12.5	63.5
432	Dera	" 5	" 29	2.3	0.26	9	63.5
433	Baggi.	" 5	" 29	2.3	0.24	10	65.5
434	Ratti	" 5	Sept. 8	2.5	0.3	10	64
435	Dorin.	" 5	Aug. 29	2.1	0.29	9	64
436	Pilli.	" 5	" 29	2.3	0.3	10	65
437	Walu.	" 5	" 29	2.3	0.27	9	63.5
438	*Lohi	" 28					
439	Khel	" 5	" 29	2.6	0.29	10	63.5
*b*439	. . . .	" 5	" 29	2.3	0.3		
440	Shega.	" 5	" 29	2.3	0.3	11	63
441	Awal No. 1	" 5	" 29	2.20	0.27	11	63
442	" No. 2	" 5	" 29	2.3	0.27	12	63.5
443	Arizona Indian	" 5	" 29	2.9	0.25	12	64
444	Archer's Prolific	" 12	Sept. 8	3.1	0.37	12	52.5
445	Dattel	Aug. 12	" 20	3.45	0.28	1	43
446	Daub 1	July 12	" 12	4.01	0.32	12	54
447	Farrie's Durum	" 23	" 8	3.67	0.33	9	52.5
448	Barwick.	" 23	" 12	3.1	0.3	14	55.5
449	*Early Jasper.						
*b*449	. . . .	" 14	" 8	3.58	0.28	15	61
449½	. . . .	" 14	" 8	3.26	0.3	8	55
450	Bancroft	" 12	" 8	3.0	0.23	12	61
451	Toronto.	" 12	" 8	2.85	0.35	9	50
452	Banater.	" 12	" 12	3.26	0.23	17	65
453	Paros.	" 12	" 8	3.26	0.25	18	61.5
454	Cape	" 14	" 12	3.0	0.28	15	51.5
455	Nashi	" 12	" 12	3.33	0.21	12	57
456	Hudson's	" 12	" 12	3.1	0.33	5	50
457	Murray River.	" 12	" 8	3.42	0.33	12	58.5
458	Green Mountain.	" 12	" 8	3.42	0.4	11	58
459	Stockton	" 12	" 8	3.26	0.26	6	62
460	Cordova.	" 14	" 8	3.58	0.35	10	56

*This is a winter variety.

TABLE III (Continued).—*Wheat, 1898.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of grain from 10 feet of row	Weight per bu.
				feet	*feet*	*oz.*	*lbs.*
461	Little Club	July 14	Sept. 8	2.94	0.15	10	56.5
462	Algerian	" 12	" 8	3.5	0.26	17	63
463	Carter's 1.	" 19	" 8	3.72	0.33	10	57.5
464	Laird's Prolific	" 19	" 8	3.59	0.38	11	55.5
465	Borneo.	" 14	Aug. 31	3.45	0.26	23	61.5
466	Reiti 1	" 23	Sept. 12	4.04	0.37	6	54
467	Veneta.	" 23		3.88	0.33	7	49
468	Varlsotta.	" 23	" 12	3.35	0.33	11	58.5
469	Noah	" 19	" 8	3.26	0.35	9	57
470	Belolourka	" 12	" 8	3.4	0.21	17	64
471	Reiti 2	" 19	" 12	3.26	0.35	7	53
472	Bordeaux.	" 23	" 8	3.59	0.3	12	56
472½		" 19	" 8	3.26	0.36	8	55.5
474	Blood Red	Aug. 4					
475	Herisson	July 19	" 12	3.29	0.16	21	54.5
476	White Flanders.	Aug. 12	" 15	3.52	0.36		
477	*Australian	" 12					
478	Fleck.	July 19	" 8	3.4	0.39	12	59
478½		" 23	" 12	3.43	0.33	9	54
479		" 19	" 12	3.1	0.15	11	53.5
480		" 14	" 12	3.06	0.17	10	56.5
481		" 14	" 12	3.52	0.35	9	51
482		" 12	" 8	3.51	0.37	10	59
483		" 12	" 8	3.26		8	60
484		" 14	" 8	3.59	0.4	8	59
485		" 12	" 8	3.0		7	54
486		" 19	" 8	3.26	0.3	8	59.5
487		" 12	" 8	3.26		9	60
488		" 14				10	60.5
489		" 19	" 8			7	56
490		" 19	" 12	2.64	0.23	4	52
491		" 12	" 8			9	58.5
492		" 19	" 8	3.26	0.3	9	56.5
493		" 19	" 8	3.0	0.41	5	55
494		" 19	" 8	3.59		10	58
495		" 14	" 8	3.0		8	57
496		" 19	" 8	3.5		10	57.5
497		" 19	" 8	3.3		10	60.5
499		" 12	" 8	2.94	0.28	1	52
499½		" 19	" 8	3.26	0.3	9	57
500		" 12	" 8	3.26		10	60
502		" 19	" 8	3.59	0.39	10	57
503		" 12	" 8	3.5		9	58
504		" 19	" 8	3.56		15	60
505		" 12	" 8	3.0		16	60
506		" 12	" 8	3.26		15	59
507	*	Aug. 23					
508	*	" 27					
509	*	" 17					
510		July 28	" 12	3.55	0.39		
511	*	Aug. 12					
512	*	" 12					
513	*	" 27					
514	*	" 30					
515	*	" 23					

*This is a winter variety.

TABLE III (Concluded).—*Wheat, 1898.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of grain from 10 feet of row	Weight per bu.
				feet	*feet*	*oz.*	*lbs.*
516		Aug. 12	Sept. 15	3.1	0.31	1	49
517	*	“ 4					
518	*	“ 30					
519	*	“ 23					
520	*	“ 23					
521	*	“ 23					
522		“ 4	“ 20	3.85	0.35	2	58
523	*	“ 27					
524		“ 12	“ 20	3.85	0.41	1	36
525	*	“ 23					
526	*	“ 17					
527	*	“ 27					
528	*	“ 23					
533	*	“ 27					
533½	*	“ 27					
534	*	“ 23					
6534	*	“ 23					
535	*	“ 30					
536	*	“ 23					
537		“ 17	“ 15	3.39	0.35	4	52
538	*	“ 30					
539	*	“ 30					
540		“ 19	“ 12	3.0	0.3	6	53
541		“ 4	“ 15	3.2	0.26	1	47.5
542		“ 4	“ 15	3.2	0.26	2	47.5
543		“ 4	“ 15	3.2	0.26	1	41.5
544	*	“ 4					
545		July 12	“ 12	2.75	0.32	9	62.5

*This is a winter variety.

TABLE IV.—*Wheat, 1899.*

This gives the results of the second year's trial of all the varieties reported in Table III which matured seed in 1898. One row 10 feet long of each variety was planted. The rows were 20 inches apart.

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of grain from 10 feet of row
				feet	*feet*	oz.
1	Minnesota Fife	July 28	Sept. 8	2.8	0.33	7
2	White Fife		" 8	3.26	0.33	3
3	Sherman	" 20	" 8	2.8	0.28	6
4	White Russian	" 24	" 8	2.8	0.28	6
5	Odessa		" 16	2.9	0.35	2.5
6	*Eldorado					
7	Soft Australian	" 28	" 16	3.0	0.3	4.5
8	Defiance	" 28	" 16	3.0	0.3	3
9	Champion	" 28	" 16	2.9	0.35	5
10	Oregon Club	" 28	" 16	3.0	0.25	3
11	Hard Australian	" 28	" 16	3.5	0.33	7
12	Sonora	" 14	" 16	2.5	0.23	3
13	White Mexican	" 24	" 8	3.26	0.28	10
14	Improved Fife	" 28	" 8	3.26	0.3	8
16	Brooks	" 28	" 8	3.6	0.35	9.5
17	Rio Grande	" 20	" 8	3.4	0.35	8
18	Canada Club	" 24	" 8	3.26	0.25	5.5
19	Judkin	" 28	" 8	3.4	0.36	9.5
20	Lost Nation	" 24	Aug. 30	3.26	0.33	9
21	Touzelle	" 14	Sept. 8	3.2	0.3	10
22	Australian Club	" 24	" 8	3.26	0.35	14.5
23	Golden Globe		" 16	3.6	0.36	10.5
24	Mediterranean Spring	" 24	" 8	3.6	0.33	11.5
25	China Tea	" 24	" 8	3.75	0.35	8.5
26	Chili	" 20	" 8	3.26	0.3	16
27	China Spring	" 24	" 16	3.8	0.35	5
28	Egyptian	" 28	" 16	3.6	0.23	2.5
29	Saxon Fife		" 16	3.26	0.3	4
30	Dominion	" 28	" 16	3.26	0.3	3
31	Prussian	" 28	" 8	3.0	0.25	7
32	Golden Drop	" 28	" 8	3.26	0.3	8
33	Pringle's No 6	" 24	" 8	3.26	0.3	8
34	" No. 4	" 28	" 8	4.0	0.3	10.5
35	" No. 5	" 24	" 8	3.59	0.27	9
36	Winter Australian	" 28	" 16	3.5	0.3	7.5
38	*Fultz					
39	Midge Proof	" 28	" 16	3.5	0.33	7
40	Black Centennial	" 28	" 8	3.6	0.25	10
41	Hedgerow	" 24	" 16	2.8	0.16	7
42	Granite	" 24	" 16	3.0	0.3	6
43	Italian	" 14	" 8	3.4	0.23	1.5
44	New York Flint	" 24	" 8	3.26	0.3	11
45	Bald Baltic	" 20	" 8	3.1	0.3	9.5
48	Red Orange	" 24	" 8	3.4	0.4	8
50	Perkey	" 14	" 8	2.9	0.25	12
51	Hybrid No. 10	" 28	" 16	3.6	0.36	4.5
52	Golden Chaff	" 20	" 8	3.25	0.33	8
53	Med'ranean Red Chaff	" 28	" 16	3.4	0.3	6
54	Velvet Chaff		" 16	3.8	0.33	5
55	Turkey	" 28	" 16	3.2	0.28	7
56	Sardonyx		" 16	3.6	0.33	5
57	Amethyst		" 16	3.6	0.35	8

*Damaged by gophers.

TABLE IV (Continued).—*Wheat, 1899.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of grain from 10 feet of row
				feet	*feet*	*oz.*
58	Ruby		Sept. 16	3.59	0.35	3
59	Jasper	July 24	" 8	3.8	0.33	8.5
60	Sapphire	" 20	" 8	3.26	0.33	7
r60		" 28	" 8	4.0	0.38	4.5
61	Chalcedony	" 28	" 8	3.7	0.3	11.5
62	Emerald	" 28	" 8	3.8	0.4	9
63	Black Chaff	" 24	" 16	3.7	0.23	5
b63			" 16	3.7	0.3	2
64	Cretan	" 24	" 16	3.85	0.23	7
65	Andriola Red	" 24	" 8	3.4	0.25	12
66	" Amber	" 20	" 8	3.26	0.23	6
67	Purple Chaff	" 24	" 8	3.4	0.16	12.5
68	Boughton	" 28	" 16	3.26	0.18	10
70	Anautka	" 20	" 16	3.9	0.3	11.5
71	Fountain	" 28	" 16	3.9	0.33	11
72	Palestine		" 16	3.75	0.4	7
73	White Chaff (smooth)	" 24	Aug. 30	3.26	0.25	10.5
76	Perfection	" 28	Sept. 8	3.5	0.3	8.5
77	German Fife	" 24	" 8	3.8	0.35	11
78	Mammoth	" 28	" 16	3.7	0.35	5
80	Samara	" 24	" 16	3.6	0.2	6
81	Durum	" 20	" 16	3.6	0.2	8.5
82	Saratov	" 24	" 8	3.5	0.3	10
83	Ames	" 20	" 8	4.0	0.23	10
84	Moscow	" 24	" 8	3.6	0.3	9
85	Knapp	" 24	" 8	3.7	0.25	12
86	Scotch Fife	" 28	" 16	4.0	0.3	7
87	Doty	" 20	Aug. 30	3.5	0.25	11
88	Meekins	" 20	Sept. 8	3.8	0.33	6
89	White Michigan	" 29	" 8	3.5	0.33	8
90	Rickenbrode	" 29	" 16	3.55	0.33	5.5
93	Black Beard	" 20	" 8	3.7	0.25	9
98	German Amber		" 16	3.0	0.36	0.5
100	Dallas		" 16	3.5	0.39	5.5
102	Finlay					
110	Propoe	" 24	" 8	3.26	0.3	10
112	Red Clawson					
117	Big May	" 28	" 8	3 4	0.33	10.5
118	Sardius	" 29	" 8	3.8	0.3	15.5
119	Chrysolite	" 24	" 8	3.26	0.33	6.5
120	Beryl	" 24	" 8	3.26	0.28	8.5
122	Jacinth	" 20	Aug. 30	3.26	0.26	12
123	Carnelian	" 28	Sept. 16	3.5	0.25	10
124	Agate	" 24	" 16	3.5	0.25	10.5
125	Onyx	" 28	" 16	3.6	0.28	11.5
126	Opal	" 28	" 16	3.5	0.26	
127	Garnet	" 30	" 16	3.8	0.33	
128	Tourmaline	" 28	" 8	3.8	0.15	12
129	Felspar	" 28	" 16	3.26	0.28	3
131	Casaca		" 8	3.75	0.33	7.5
133	Tuscan	" 29	" 16	3.5	0.33	
135	Tuskana					
136	Pearl			3.26	0.4	5
138	White Chaff	" 24	" 16	3.26	0.25	11.5
145	Red Oregon Club		" 16	3.26	0.28	13
146	Hedgerow					
147	Aowse	Aug. 25		3.8	0.4	1.5

TABLE IV (Continued).—*Wheat, 1899.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of grain from 10 feet of row
				feet	*feet*	oz.
148	Monmouth	July 28	Sept. 16	3.6	0.4	6
149	Russian (spring)	" 28	" 8	3.59	0.33	7.5
150	Vermillion	" 28	" 8	3.7	0.4	13
152	Edenton Fife	" 29	" 16	3.7	0.35	
153	Nox No. 2	" 29	" 16	3.8	0.36	6.5
154	" No. 1	" 30	" 16	3.8	0.35	
155	" No. 4	" 20	Aug. 30	3.26	0.3	
156	" No. 3	" 24	Sept. 8	3.59	0.33	14
157	" No. 5	" 28	" 16	4.3	0.35	11
158	Pringle's No. 17	" 28	" 16	3.85	0.35	8.5
159	" No. 18	" 28	" 16	3.8	0.3	14
160	Wales	" 28	" 16	3.7	0.3	12.5
161	Dead Sea		" 16	3.9	0.3	8.5
162	Northcote's White	" 28	" 16	3.5	0.25	11
163	" Amber	" 24	" 16	3.5	0.3	8.5
164	White May	" 20	" 8	3.26	0.3	13
165	Cat Mountain	Aug. 16	" 16	3.28	0.33	3.5
166	Reed Straw					
167	Cayaga	July 24	" 8	3.7	0.35	14.5
168	Black Chaff		" 16	3.26	0.3	8.5
169	Gneiss	" 28	" 8	3.59	0.33	12.5
172	Quartz	" 20	" 16	2.9	0.33	6
174	Red Mediterranean	" 28	" 16	3.4	0.33	5
*b*174		" 30	" 16	3.28	0.3	7
175	French Imperial	Sept. 1				
176	Nebraska	July 20	" 8	3.0	0.28	11.5
177	White's	" 24	" 8	3.9	0.4	10.5
178	Kivet	Sept. 16				
179	Rust Proof	July 30	" 16	3.75	0.35	12
180	Baltimore	Sept. 16				
182	Purple Straw	July 20	" 8	3.15	0.3	12
184½				3.5	0.33	3.5
186	Wintergreen	Sept. 16				
188*a*			" 16	3.6	0.28	11
188*b*		July 20	" 8	3.26	0.3	7
188*c*		" 20	" 8	3.59	0.3	10
189	Hunter's Spring	Sept. 16				
191	Hardwick	July 20	" 8	3.26	0.25	11.5
192	Geiger	" 20	" 8	3.26	0.28	10
193	Hornblende	" 24	" 16	3.6	0.28	9
194	Sea Island	" 28	" 8	3.59	0.25	10
195	Edmenton	" 24	" 8	3.9	0.36	6
196	Winnipeg Russian	" 28	" 8	3.59	0.3	8
197	Manitoba	" 29	" 16	3.8	0.3	13
198	Winnipeg	" 24	" 16	4.0	0.28	7
199	Russian White		" 16	4.1	0.36	5
200	Hallett's Pedigree		" 16	3.7	0.33	8
201	Sibley's No. 1		" 16	3.8	0.26	1.5
202	French Black Chaff	Aug. 16		3.0	0.4	
203	Rural	July 28	" 16	4.0	0.25	3
204	Velvet Club	Sept. 1				
205	Austrian	July 28	" 16	3.26	0.3	6.5
206	Bohemian	Sept. 16				
207	Whittington	July 24	" 8	3.28	0.28	8
207*a*		" 24	" 16	3.5	0.3	3.5
208	Snowflake	" 24	" 8	3.1	0.26	6.5
209	Beardless Velvet	" 24	" 8	3.1	0.25	6

TABLE IV (Continued).— *Wheat, 1899.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of grain from 10 feet of row
				feet	*feet*	*oz.*
210	Tagarog	July 24	Sept. 8	3.26	0.28	7
212	China White	" 24	" 8	3.26	0.33	11
213	" Red	" 28	" 16	2.7	0.23	
214	Missouri Turkey	Aug. 16				
216	California Walker					
222	Saskatchewan	July 30	" 16	3.6	0.33	7
223	Rye	" 28	" 16	3.6	0.33	9
224	Frankenstein	Aug. 10		3.4	0.39	4.5
225	March	July 24	" 16	3.0	0.3	8.5
225½		Aug. 10		3.26	0.30	3
226						
227	Flourelle					
228	Victoria	" 5	" 16	3.6	0.33	8
230	White Velvet	" 24	" 16	3.5	0.33	15.5
231	Verplank	Sept. 16				
233	Sandomirk	July 20	" 16	3.6	0.25	11
234	Wicker	" 28	" 16	3.26	0.26	10
238	Shumaker	" 24	" 8	3.75	0.35	7
240	Snake River	" 30	" 16	3.6	0.3	5
241	Red River	" 28	" 16	3.8	0.4	4.5
242	Upland	Aug. 5	" 16	3.7	0.3	5.0
243	Hard Manitoba	" 5	" 16	3.6	0.33	6.5
244	Santa Fe	July 29	" 16	4.0	0.3	7
255	Tasmanian Red	Aug. 16	" 16	2.8	0.33	0.5
257	Treadwell	" 5	" 16	3.6	0.35	4
280	Uxbridge	" 5	" 16	3.5	3.28	5.5
283	Rust Proof (soft)	" 5	" 16	3.26	3.33	6
288	Dand Khan No. 2	July 14	" 8	2.4	0.25	13
292	Fulcaster			3.1	0.4	1.5
299	Tappahannock					
300	Gypsum	Aug. 5	" 16	3.45	0.33	5.5
301	Basalt	" 5	" 16	3.7	0.35	6
302	Flourspar	July 29	" 16	3.7	0.3	8
303	Granite	" 28	" 8	3.45	0.35	11
304	Platinum	" 29	" 16	3.6	0.4	8
305	Porcelain	" 24	" 8	3.5	0.35	10.5
306	Silica	" 25	" 8	3.26	0.3	13
307	Trap	Aug. 5	" 16	3.6	0.35	8.5
309	Pool's Red	" 5				
319	Deitz Red	" 5				
321	" Amber					
322	Dayton	" 15				
331	Weeks	July 24	" 8	3.45	0.3	15
332	Hoover	Aug. 5				
334	Valley	Sept. 1				
336*a*		Aug. 5		3.6	0.34	12
336*b*		" 5	" 16	3.7	0.35	5.5
337	Genoese	July 28	" 8	3.59	0.3	13
342	Indian	" 28	" 8	3.0	0.3	4
343	Sheriff (four-rowed)	" 14	" 8	3.8	0.26	7.5
344	Baart	" 24	" 16	3.0	0.35	6
347	Ward's Prolific	" 28	" 16	4.0	0.45	7.5
348	Roseworthy	" 14				
*b*348		" 14	" 8	2.0	0.23	8
349	Australian Purple Straw	" 20	" 8	3.26	0.3	13.5
350	Australian Indian	" 14	" 8	2.1	0.2	8
355	Du Toits	" 14	" 8	3.0	0.3	14.5

TABLE IV (Continued).—*Wheat, 1899.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of grain from 10 feet of row
				feet	*feet*	oz.
357	Steinwedel's Early. . .	July 20	Sept 8	3.2	0.38	9.5
358	Rattling Tom	" 20	" 8	3.28	0.28	10
359*a*	. . . .	" 20	" 16	3.4	0.2	
359*b*	. . . .	" 20	" 16	3.3	0.25	5
360	Missogen.	" 24	" 16	4.0	0.35	6.5
361	Atlanti.	" 24	" 16	3.4	0.25	8
363	Sadoza.	" 24	" 8	3.5	0.28	10.5
364	Curtis' White.	" 24	" 8	3.7	0.35	13.5
365	Seven Headed Red. . .	" 24	" 16	3.95	0.25	6.5
366	Ontario	" 20	" 16	3.1	0.15	8
366½	. . . .	" 20	" 16	3.3	0.2	7
377	Egyptian No. 8.	" 28	" 16	3.65	0.35	16
383	" F	" 20	" 16	3.5	0.3	7
388	Carter's A	" 29	" 16	3.65	0.3	
389	" B.					
393	" F.	Sept 15				
397	" J.	Aug. 5	" 16	3.6	0.25	2.5
398	" L.	Sept. 8				
398½	. . . .					
400	Algerian No. 1.	Jnly 20	" 8	3.26	0.2	12.5
401	" No. 2.	" 20	" 8	3.26	0.2	18
401½	. . . .	" 20	" 8	3.26	0.28	15.5
b402	. . . .	" 20	" 8	3.26	0.25	10.5
402½	. . . .	Aug. 20				
404	Galland Hybrid	" 5	" 16	3.8	0.25	3
405	Zeland	" 5	" 16	3.4	0.36	4
406	Lanneurde Mars	" 5	" 16	3.0	0.35	5
407	Berthoud	Sept. 1				
408	Mold's White	" 16				
409	" Red.	Aug. 5	" 16	3.1	0.36	7.5
410½	. . . .	July 24	" 16	2.5	0.3	7
411	Hungarian	Aug. 5				
412	Prize.	July 20	" 8	3.7	0.23	16
413	Little Wonder	" 28	" 8	3.5	0.28	11.5
414	Champion	" 24	" 8	3.5	0.25	14.5
416	Oakshot's Champion. . .	" 20	" 8	3.59	0.26	14.5
418	Fillbag.	" 14	Aug. 30	2.8	0.2	10
419	McDowell	" 24	Sept. 8	3.45	0.26	11
420	Young's	" 20	" 8	3.85	0.25	9
421	California Red.	" 14	" 8	3. 1	0.26	6.5
422	Little Club	" 24	" 16	2. 8	0.15	
424	Essex	" 24	" 8	3. 5	0.25	8
425	Purple.	" 24	" 8	3.59	0.25	10.5
426	Tuscan.	" 24	" 8	3.35	0.25	9
427	Jubilee	" 14	" 8	3.26	0.3	13
428	Leake's	" 24	" 8	3.4	0.26	10
431	Rodi.	" 14	Aug. 30	2.7	0.25	11.5
431½	. . . .	" 14	Sept. 8	2.8	0.23	14
431⅓	. . . .	" 14	" 8	2.8	0.26	10
432	Dera.	" 14	" 8	2.8	0.25	12.5
433	Baggi	" 14	Aug 30	2.7	0.23	11
434	Ratti	" 14	Sept. 8	2.93	0.25	10
435	Dorin	" 14	" 8	2.5	0.23	14
436	Pilli	" 14	" 8	2.5	0.3	13.5
437	Walu	" 14	" 8	2.61	0.23	4.5
438	Lohi.	" 14	" 16	3.15	0.2	
439	Khel.	" 14	Aug. 30	2.0	0.25	7.5

TABLE IV (Continued).—*Wheat, 1899.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of grain from 10 feet of row
				feet	*feet*	*oz.*
439		July 14	Aug. 30	2.8	0.25	8.5
440	Shega	" 14	" 30	2.8	0.23	10.5
441	Awal No. 1	" 14	Sept. 8	2.65	0.2	5
442	" No. 2	" 14	" 8	2.4	0.23	6.5
443	Arizona Indian	" 14	Aug. 30	3.0	0.21	13
444	Archer's Prolific	Aug. 5	Sept. 16	3.7	0.25	11
445	Dattel					
446	Daub I	July 20	" 16	4.1	0.25	12.5
447	Farrie's Durum	" 28	" 16	3.6	0.3	7
448	Barwick	" 28	" 16	3.75	0.3	6.5
449	Early Jasper	" 20	" 8	4.0	0.2	
449½		" 28	" 16	3.65	0.2	12
450	Bancroft	" 14	" 8	2.85	0.2	4.5
451	Toronto	July 20	Sept. 8	3.26	0.3	10.5
452	Banater	" 24	" 16	3.8	0.24	9.5
453	Paros	" 24	" 16	3.8	0.22	12
454	Cape	" 20	" 8	3.26	0.25	15.5
455	Nashi	" 20	" 8	3.4	0.18	6
456	Hudson's	" 20	Aug. 30	3.1	0.21	16
457	Murray River	" 24	Sept. 8	3.1	0.25	10
458	Green Mountain	" 20	" 8	3.5	0.33	10
460	Cordova	" 24	" 8	3.5	0.33	8.5
461	Little Club	" 24	" 16	3.0	0.18	9.5
462	Algerian	" 20	" 8	3.45	0.23	14
463	Carter's I	Aug. 5	" 16	3.8	0.25	6
464	Laird's Prolific	July 24	" 8	3.6	0.35	12
465	Borneo	" 20	Aug. 30	3.2	0.23	15.5
466	Reiti 1	Aug. 20				
467	Veneta	" 20				
468	Varlsotta	" 20				
469	Noah	July 29	Sept. 8	3.8	0.3	4.5
470	Belolourka	" 20	" 8	4.0	0.21	12.5
471	Reiti 2	Aug. 20				
472	Bordeaux	" 5	" 16	4.0	0.25	7
472½		" 5	" 16	3.7	0.3	12.5
475	Herisson	July 28	" 8	3.8	0.15	9
478	Fleck	" 28	" 8	3.5	0.35	10
478½		Aug. 20				
479		July 28	" 16	3.45	0.15	12.5
480		" 28	" 16	3.4	0.15	4.0
481		" 28	" 16	3.25	0.3	6.5
482		" 24	" 8	3.8	0.35	6
483		" 28	" 16	3.6	0.3	11
484		" 28	" 16	3.7	0.35	6
485		" 20	" 8	3.5		12.5
486		" 28	" 8	3.5	0.25	10
487		" 20	" 8	3.55		7
488		" 24	" 8	3.8		9
489		" 20	" 8	3.59	0.25	10
490		" 20	" 8	3.50	0.26	7.5
491		" 20	" 8	3.59	0.3	12
492		" 24	" 16	3.5	0.35	7
493		" 28	" 8	3.91	0.35	9
494		" 28	" 8	3.75	0.4	9.5
495		" 20	" 8	3.59	0.35	11
496		" 20	" 8	3.55	0.33	9
497		" 24	" 8	3.4	0.28	13

TABLE IV (Continued).—*Wheat, 1897.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of grain from 10 feet of row
				feet	*feet*	*oz*
499	....	July 20	Aug. 30	3.26	0.23	16.5
499½	....	" 24	Sept. 8	3.4	0.25	9.5
500	....	" 20	Aug. 30	3.1		14.5
501	....	" 28	Sept. 16	3.65	0.35	5
502	....	" 28	" 16	3.55	0.3	8
503	.. ..	" 28	" 16	3.65	0.2	8.5
504	....	" 24	" 8	3.6	0.33	10.5
505	....	" 20	" 8	3.65	0.28	12.5
506	....	" 20	" 8	3.26	0.25	7
516	....	Sept. 10				
517	....	" 10				
522	....	" 15				
524	....					
537	... .	" 1				
540	....	July 28	" 16	3.55	0.35	12.5
541	. ...	Sept. 15				
542	....	" 15				
543	....	" 15				
544	....	" 1				
545	....	July 20	" 8	2.35	0.25	13

TABLE V.—*Oats, 1896.*

This gives the results of oats grown from seed furnished by Professor Vestal of New Mexico during the season of 1896. One row 50 feet long of each variety was planted. The rows were 18 inches apart.

No.	NAME	Date headed		Date ripe		Height	Length of heads	Yield of straw and grain from 50 feet of row		Yield of grain from 50 feet of row		Weight per bu.
						feet	*feet*	*lbs.*	*oz.*	*lbs.*	*oz.*	*lbs.*
2	Board of Trade	July	13	Sept.	4	3.8	0.9	12	10	4	11	42
3	Australian	"	17	"	4	3.6	0.85	11	4	4	6	45
5	Pringle's Hulless	"	13	"	17	3.7	0.9	8	13	2	11	46.5
6	" No. 6	"	23	Oct.	7	4.0	0.8	9	2	2	12	38
7	" No. 4	"	25	"	7	3.85	0.8	8	9	2	14	38
8	" No. 6	"	23	Sept.	17	4.0	1.0					40
9	Belgio-Russian	"	25	"	17	4.1	0.8	7	3	2	8	37
11	Russian Black	"	23	"	17	4.0	0.7	8	12	3	4	40
13	New Zealand	"	13	"	4	3.8	0.95	11	2	4	2	43
14	White Russian	"	23	Oct.	7	4.2	0.9	10	14	1	13	39
15	Black Tartarian	"	31			4.0	0.9	9	3	1	12	31
16	Early Yellow	"	31	"	7	3.9	1.35	8	9	1	12	39
17	Early Poland	"	13	Sept.	4	3.2	0.7	10	13	4	5	43
18	Poland	"	27	Oct.	7	3.6	0.95	8	4	1	7	38
19	Potato	"	31	"	7	4.0	0.85	7	12		12	36
21	Chinese Hulless	"	23	Sept.	17	4.3	1.0	12		2	14	47
23	Pringle's Excelsior	"	11	"	17	3.7	0.9	9	4	2	11	50
24	Rust Proof	"	17	Aug.	31	2.6	0.4	7	15	3		35
28	South Carolina Black	"	13	Sept.	8	3.9	0.7	14	14	5	10	39
31	Clydesdale	"	23	"	8	4.6	1.0	14	3	4	10	44
32	Colorado Yellow	"	20	"	17	3.8	0.95	11	8	3	4	41
34	Austrian No. 2	"	13	"	8	4.0	1.0	10	4	4	14	45
35	American Beauty	"	17	"	4	3.6	0.9	9	9	3	11	41
39	Black Champion	"	23	"	17	3.45	0.75	3	14	3	3	36
40	Monarch	Aug.	8	Oct.	7	4.15	0.7	10	4		9	32
42	Race Horse	July	17	Sept.	17	2.5	1.0	7	5	2	3	45
44	Swiss Black	Aug.	3	Oct.	5	4.0	0.65	11	3	2	5	40
45	Victoria	July	17	Sept.	4	3.5	0.7	8	14	3	1	
46	Hopetown	"	23	"	17	3.6	0.7	10		4	6	40
47	Waterloo	"	31	"	17	4.0	0.85	11	11	4	10	38
49	Silesian	"	20	"	2	3 9	0.9	10	4	3	9	42
50	Golden Giant	"	31	"	31	4.6	1.2	9	7	1	9	35
51	Orient	"	31	Oct.	7	4.0	1.25	10	6	1	11	41
52	Lost	"	31	"	5	4.2	1.35	10	4	1	11	37
53	Improved American	"	25	Sept.	17	4.1	0.8	10	11	3	8	38
54	Hargett's White	"	20	"	8	3.4	0.9	12	3	4	8	43
55	Excelsior	"	25	"	17	4.0	0.75	14	10	4	14	40
56	Highbred	"	13	"	2	3.8	0.8;	9	14	3	11	45
59	Cape	June	29	Aug.	15	1.5	0.3	4	4	1	8.5	40
66	Algerian	July	6	Sept.	4	2.8	0.45	6	5	2	6	

TABLE VI.—*Oats, 1897.*

This gives the results of the second year's trial of all the varieties reported in Table V. One row 50 feet long of each variety was planted. The rows were 18 inches apart.

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of straw and grain from 50 feet of row		Yield of grain from 50 feet of row		Weight per bu
				feet	*feet*	*lbs.*	*oz.*	*lbs.*	*oz.*	*lbs.*
1	White Dutch	July 20	Sept. 8	3.5	0.7	9	12	2	8.5	40
2	Board of Trade	" 22	" 3			8		2	0.5	43
3	Australian	" 22	" 11	4.1	0.85	8	10	2	4	39
5	Pringle's Hulless	" 20	" 4	3.35	0.93	7	12	2	1	43.5
6	" No. 6	" 22	" 11	3.65	0.88	10	6	2	14	40
7	" No. 4	" 26	" 11	3.67	0.75	9	13	2	12	[illegible]
8	" No. 6	" 28	" 22	3.87	0.78	10	11	2	13	[illegible]
9	Belgio-Russian	" 28	" 8	3.33	0.72	7	2	2	12	31.5
11	Russian Black	" 26	" 22	3.34	0.92	12	4	2	9	
13	New Zealand	" 28	" 22	3.66	1.11	9	5	2	12.5	36
14	White Russian	" 28	" 23	4.3	0.86	19	1	2	2	[illegible]
15	Black Tartarian	" 28	" 8	3.6	0.65	7	8	1	1	
16	Early Yellow	" 31	" 11	3.89	0.79	11	1	3	2.5	35
17	Early Poland	" 26	" 11	3.74	0.92	6	11	2	6	40.5
18	Poland	" 28	" 13	3.63	0.84	10		2	8	33
19	Potato	Aug. 9	" 22	3.33	0.93	7	3	2	[illegible]	[illegible]
21	Chinese Hulless	July 26	" 3			8	13	2	6	[illegible]
23	Pringle's Excelsior	" 20	" 4	3.68	0.77	7	2	1	10	[illegible]
24	Rust Proof	" 26	" 11	3.26	0.45	8	8	2	2	
28	South Carolina Black	" 20	" 22	3.8	0.75	11	13	3	1	34.5
31	Clydesdale	" 26	" 3	3.53	0.88	7	10	2	3	47
32	Colorado Yellow	Aug. 9	" 22	3.75	0.85	12	3	2	12	36
34	Austrian No. 2	July 22	" 11	3.92	0.8	8	12	2	11	40
35	American Beauty	" 22	" 11	3.8	0.85	9	2	3	0.5	38.5
39	Black Champion	" 26	" 11	3.27	0.6	7		2	7	[illegible]
40	Monarch	" 28	" 22	3.87	0.81	9	1	2	6	[illegible]
42	Race Horse	" 26	" 11	3.69	0.72	9	1	2	6	41
44	Swiss Black	" 20	" 22	4.0	0.7	13	2	3	14	[illegible]
45	Victoria	" 20	" 8	4.0	0.85	9	10	3	4	41.5
46	Hopetown	" 26	" 8	3.74	0.73	8	13	2	13	[illegible]
47	Waterloo	" 20	" 22	3.6	0.55	13	15	3	12	[illegible]
49	Silesian	" 20	" 22	3.7	0.65	12	11	3	9	42
50	Golden Giant		" 22	3.52	0.85	6	9	1	15	35.5
51	Orient	" 28	" 11	3.7	0.7	8	4	1	6	
52	Lost	" 26	" 22	3.48	0.74	10	6	2	3	40
53	Improved American	" 26	" 8	3.99	0.82	10	8	3	3.5	40.5
54	Hargett's White	" 20	Aug. 30	3.36	0.72	5	13	1	13	41
55	Excelsior	" 26	Sept. 8	3.91	0.68	8	4	2	15	
56	Highbred	" 20	" 3	3.77	0.75	9	14	4	4	42
59	Cape	" 8	Aug. 25	2.2	0.32	3	14	1	11	32
66	Algerian	" 28	Oct. 7	3.5	0.6	4	6	1	1	35

TABLE VII.—*Oats, 1898.*

This gives the results of the first year's trial of Professor Blount's collection of oats. The varieties reported on in Tables V and VI were originally from Professor Blount, but the varieties reported in the following table were grown from seed selected by him personally and furnished gratis to the Station. One row ten feet long of each variety was planted. The rows were 20 inches apart

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of grain from 10 feet of row	Weight per bu.
				feet	*feet*	*oz.*	*lbs.*
1	White Dutch	July 12	Aug. 15	3.29	1.03	6	39.5
2	Board of Trade	" 12	" 15	3.3	0.94	8	38.5
3	Australian	" 19	" 15	3.29	0.88	7.5	38
4	Black American	" 14	" 23	3.03	0.67	9	32.5
5	Pringle's Hulless	" 19	" 19	3.0	0.68	4.5	40
6	" No. 6	" 23	" 27	3.31	0.63	13.5	35.5
7	" No. 4	" 23	Sept. 2	3.65	0.82	10.5	36
8	" No. 6	" 23	" 9	4.24	1.08	6	35.5
9	Belgio-Russian	" 23	Aug. 27	3.29	0.84	13	37
10	Schoenon	" 23	" 27	3.1	0.81	5	37
11	Russian Black	" 19	" 27	3.3	0.75	13	37
12	Alexander	" 19	" 29	3.28	0.75	15	38
13	New Zealand	" 14	" 15	3.21	0.88	9	38.5
14	White Russian	" 23	Sept. 6	3.68	0.98	3	37.5
15	Black Tartarian	" 23	Aug. 31	3.03	0.73	10	34.5
16	Early Yellow		Sept. 6	3.22	0.82	11.5	36.5
17	Early Poland	" 19	Aug. 15	3.28	0.88	6	36
18	Poland	" 18	Sept. 6	3.55	0.7		35
20	Early Angus	" 23	Aug. 31	3.72	0.95	11	35.5
21	Chinese Hulless	" 19	" 23	3.3	0.78	4.5	47
22	Triumph	" 28	Sept. 6	4.04	0.78	8.5	35
23	Pringle's Excelsior	" 12	Aug. 19	3.27	0.72	5	40.5
24	Rust Proof	" 5	" 15	2.82	0.49	11.5	37
25	White Eureka	" 19	" 27	3.27	0.72	17	38
26	Welcome	" 19	" 16	3.31	0.88	7.5	41
27	Novelty	" 23	Sept. 6	3.55	0.88	8	34.5
28	South Carolina Black	" 5	Aug. 15	3.05	0.63	10.5	36
29	Golden Sheaf	" 19	" 27	3.31	0.85	16.5	39.5
30	Probster	" 19	" 29	3.3	0.8	15	30
31	Clydesdale	" 12	" 15	3.31	0.79	9.5	41.5
32	Colorado Yellow	" 19	Sept. 6	4.04	0.73	14	37.5
33	Austrian No. 1	" 19	Aug. 31	4.27	0.72	19	38.5
34	" No. 2	" 12	" 17	3.31	0.9	13	41.5
35	American Beauty	" 14	" 19	3.28	0.86	13	39
36	Burpee's Welcome	" 19	" 23	3.31	0.91	7	41.5
37	Bohemian	" 19	" 27	3.32	0.91	9	40
38a		" 19	" 27	4.0	0.76	20	37
38b		" 23	" 27	3.31	0.85	13.5	38
39	Black Champion	" 23	" 29	3.67	0.76	15	33.5
40	Monarch	" 23	" 12	4.5	0.92	5	37
41	Dakota	" 19	" 23	4.0	0.75	12	39.5
42	Race Horse	" 19	Sept. 2	4.03	0.88	14	38
43	Canadian	" 19	Aug. 29	4.07	0.82	17	30
44	Swiss Black	" 28	Sept 12	4.01	0.84	12	36
45	Victoria	" 14	Aug. 16	3.58	0.72	12	38
46	Hopetown	" 23	" 29	4.08	0.72	14	37
47	Waterloo	" 19	" 27	3.65	0.77	13.5	36.5
48	Harris	June 30	" 15	2.57	0.54	6.5	29
49	Silesian	July 19	" 16	3.75	0.88	8	36
50	Golden Giant	" 28	Sept. 12	3.97	1.12	5	35
51	Orient	" 28	" 6	4.24	0.95	10.5	37
52	Lost	" 28	" 6	3.75	0.75	11	34.5

TABLE VII (Continued).—*Oats, 1898.*

No.	NAME	Date headed		Date ripe		Height	Length of heads	Yield of grain from 10 feet of row	Weight per bu.
						feet	*feet*	*oz.*	*lbs.*
53	Improved American. . . .	July	23	Aug.	27	3.88	0.77	16	36.5
54	Hargett's White.	"	19	"	16	3.75	0.92	10.5	40
55	Excelsior.	"	14	"	16	3.65	0.92	7	37
56	Highbred.	"	15	"	16	3.55	0.94	8.5	38
57	Algerian No. 1	"	12	"	27	3.75	0.82	15	39
58	" No. 2	"	5	"	16	3.11	0.72	7	31
59	Cape	June	30	"	16	2.44	0.43	3	30
62	Tasmanian	July	23	Sept.	6	4.14	0.96	10	35
63	Foxtail	"	14	Aug.	16	3.75	0.68	9	37.5
65	Farrer.	"	5	"	16	3.1	0.37	7.5	33.5
66	Algerian	"	5	"	16	3.25	0.57	8	31.5
68	. . . .			"	16	3.04	0.65	5.5	27.5
69	. . . .	"	19	"	29	3.33	0.63	15	34.5
71	. . . .	"	19	"	31	3.44	0.75	16	37
72	. . . .	"	12	"	29	4.31	0.9	4	20
73	. . . .	"	19	"	29	3.98	0.73	19	37.5
74	. . . .	"	19	Sept	2	3.85	0.81	17.5	37.5
75	. . . .	"	19	"	2	4.17	0.39	16	38.5
76	. . . .	"	23	"	2	4.5	0.91	16	38
77	. . . .	"	23	"	2	4.75	0.78	12	39
78	. . . .	"	23	"	2	4.44	0.85	7.5	33

TABLE VIII.—*Oats, 1899.*

This gives the results of the second year's trial of all the varieties reported in Table VII. One row 10 feet long of each variety was planted. The rows were 20 inches apart

No.	NAME	Date headed		Date ripe		Height	Length of heads	Yield of grain from 10 feet of row
						feet	*feet*	*oz.*
1	White Dutch	July	28	Sept.	8	2.8	0.85	6
2	Board of Trade	"	24	"	8	2.5	0.62	6.5
3	Australian	"	24	"	8	2.85	0.8	6
4	Black American.	"	24	"	8	2.8	0.7	10
5	Pringle's Hulless	"	20	Aug.	29	2.7	0.6	8
6	" No. 6	"	20	Sept.	8	3.0	0.6	11.5
7	" No. 4	"	24	"	8	3.0	0.6	10.5
8	" No. 6	"	24	"	8	3.26	0.8	11.5
9	Belgio-Russian	"	24	"	8	3.25	0.7	12
10	Schoenon.	"	24	"	8	3.26	0.7	12.5
11	Russian Black	"	20	Aug.	30	3.2	0.7	11
12	Alexander	"	20	Sept.	8	3.4	0.6	17.5
13	New Zealand	"	20	Aug.	28	3.1	0.8	10
14	White Russian	"	28	Sept.	8	3.5	0.8	15.5
15	Black Tartarian.	"	28	"	8	3.0	0.65	12
16	Early Yellow			"	8	3.0	0.8	14

TBBLE VIII (Continued).—*Oats, 1899.*

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of grain from 10 feet of row
				feet	*feet*	*oz.*
17	Early Poland	July 24	Sept. 8	3.26	0.7	10
18	Poland		" 8	3.26	0.65	12.5
20	Early Angus		" 8	3.26	0.75	12
21	Chinese Hulless	" 20	Aug. 22	3.0	0.65	5
22	Triumph		Sept. 16	3.5	0.9	8
23	Pringle's Excelsior	" 20	Aug. 22	3.1	0.6	3.5
24	Rust Proof	" 24	Sept. 8	3.5	0.75	12
25	White Eureka	" 24				15
26	Welcome	" 24	" 8	3.26	0.9	13.5
27	Novelty	" 24	" 8	3.0	0.45	11
28	South Carolina Black	" 20	Aug. 28	3.0	0.6	15
29	Golden Sheaf	" 20	" 27	3.2	0.6	9.5
30	Probster	" 24	Sept. 8	3.5	0.6	18
31	Clydesdale	" 24	" 8	3.59	0.75	10
32	Colorado Yellow	" 20	" 8	3.26	0.6	15
33	Austrian No. 1	" 20	" 8	3.26	0.65	17
34	" No. 2	" 20	" 8	3.26	0.7	15.5
35	American Beauty	" 24	" 8	3.0	0.8	12
36	Burpee's Welcome	" 24	" 8	3.0	0.7	9
37	Bohemian	" 20	Aug. 28	3.1	0.8	10
38a		" 20	" 30	3.0	0.6	12.5
38b		" 28	Sept. 8	3.0	0.65	13
39	Black Champion	" 24	" 8	3.0	0.65	10
40	Monarch		" 16	3.26	1.0	7
41	Dakota	" 28	" 8	3.6	0.8	10.5
42	Race Horse	" 24	" 8	3.26	0.65	14.5
43	Canadian	" 22	" 8	3.4	0.7	18
44	Swiss Black		" 16	3.5	0.9	6
45	Victoria	" 24	" 8	3.5	0.9	14
46	Hopetown	" 24	" 8	3.2	0.6	17
47	Waterloo	" 20	" 8	3.0	0.65	15
48	Harris	" 14	" 8	2.9		4
49	Silesian	" 20	" 8	3.0	0.7	13.5
50	Golden Giant		" 16	3.4	0.8	11
51	Orient	" 28	" 8	3.59	0.7	14
52	Lost		" 8	3.0	0.7	15
53	Improved American	" 24	" 8	3.26	0.65	21
54	Hargett's White	" 24	" 8	3.1	0.85	11
55	Excelsior	" 24	" 8	3.26	0.7	13.5
56	Highbred	" 20	" 8	3.0	0.7	16
57	Algerian No. 1	" 24	Aug. 30	3.1	0.8	22
58	" No. 2	" 16	" 30	2.5	0.4	19
59	Cape	" 14	" 28	2.3	0.35	7
62	Tasmanian	" 28	Sept. 16	3.5	0.7	10.5
63	Foxtail	" 20	" 8	3.1	0.7	12
65	Farrar	" 14	" 8	2.4	0.55	20
66	Algerian	" 28	Aug. 16	3.0	0.55	6
68		" 20	Sept. 8	3.0	0.6	16.5
69		" 28	" 8	3.0	0.65	18
71			" 16	3.5	0.7	10
72		" 28	" 8	3.59	0.8	13
73		" 24	" 8	3.45	0.7	19.5
74		" 20	" 8	3.26	0.55	23.5
75		" 20	Aug. 28	3.2	0.6	20
76		" 24	Sept. 8	3.5	0.65	16
77		" 24	" 8	3.26	0.65	18
78		" 24	" 8	3.26	0.65	23

TABLE IX.—*Barley, 1896.*

This gives the results of barley grown from seed furnished by Professor Vestal of New Mexico, during the season of 1896. One row 50 feet long of each variety was planted. The rows were 18 inches apart.

No.	NAME	Date headed		Date ripe		Height	Length of heads	Yield of straw and grain from 50 feet of row		Yield of grain from 50 feet of row		Weight per bu.
						feet	*feet*	*lbs.*	*oz.*	*lbs.*	*oz.*	*lbs.*
1	*Smooth Hulless	July	11	Aug.	17	2.2	0.26	9	9	3	2	64
2	Winnipeg No. 1	"	6	Sept.	7	2.5	0.28	10	8	4	2	56
4	*New Zealand	"	17	"	7	3.7	0.4	12	11	5	4	54.5
5	Chevalier	"	25	"	7	3.45	0.4	14	14	4	12	52
7	*Winter (6-rowed)	"	11	"	5	2.61	0.15	13	7	6	10	46
8	Purple	"	6	Aug	25	2.5	0.16	12	1	5	7	54
9	Melon	"	11	"	31	3.4	0.25	15	3	5	15	52
10	Del Norte	"	9	"	27	2.8	0.23	8		3	2	62
11	Triumph	"	20	Sept.	7	3.65	0.35	8	6	4	6	47
13	Kilma	"	11	Aug.	27	2.7	0.325	13	1	5	9	53
14	Scotch Annat	"	11	Sept.	5	3.26	0.4	12	1	4	5	52
15	Black	"	11	Aug.	25	2.7	0.26	11	6	5	1	51
16	Palestine	"	20	Sept.	7	3.35	0.36	9	15	3	10	52
17	Animate	"	25	"	7	3.6	0.4	14	3	4	12	51
18	Guymalye	"	6	Aug.	24	2.5	0.23	6	11	3	8	55
19	Manchurian	"	25	Sept.	7	3.4	0.45					
20	Frick's	"	11	"	5	3.0	0.32	14		5	13	53
21	**Spring (4-rowed)	"	13	"	7	3.0	0.3	**				50
22	Eufurt	"	23	"	7	3.2	0.4	14	6	4	14	54
23	Nepaul	"	11	Aug.	29	3.2	0.33	11	9	4	7	63.5
24	Winter (4-rowed)	"	11	"	27	3.26	0.3	11	8	4	10	45
26	Sibley's Improved	"	17	Sept.	7	3.4	0.3	11	1	4	6	46
27	Mansury	"	11	Aug.	27	3.1	0.33	12	11	5	8	
28	Adams' Heavy	"	11	"	24	3.1	0.3	14	12	6	7	51
29	Sibley's Pearl	"	11	"	24	3.3	0.33					51
32	Berkley	"	11	"	24	3.5	0.32	9	10	3	5	50
33	Zeochrit	"	11	"	31	3.26	0.29	14	5	5	5	53
34	Perigerste	"	23	Sept.	7	3.5	0.4	14	6	5	7	53
40	Algerian No. 2	"	6	Aug.	31	2.7	0.24	10	4	6	10	47
41	" No. 3	"	6	"	31	2.3	0.22	10	14	5		49
42	Battledore	"	23	Sept.	7	3.4	0.4	15	12	5	8	52.5
46	Himalaya	"	6	"	7	2.5	0.2	9	9	4	12	64½
47	Carter's Prize	"	23	"	7	3.6	0.4	17	2	4	10	52
48	Goldthorpe	"	23	"	7	3.4	0.27	14	6	4	15	

*Seed not obtained from the New Mexico Station.

**Misnamed, as it is a 6-rowed variety. Part of crop lost.

TABLE X.—*Barley, 1897.*

This gives the results of the second year's trial of all the varieties given in Table IX. One row 50 feet long of each variety was planted. The rows were 18 inches apart.

No.	NAME	Date headed		Date ripe		Height	Length of heads	Yield of straw and grain from 50 feet of row		Yield of grain from 50 feet of row		Weight per bu.
						feet	*feet*	*lbs.*	*oz.*	*lbs.*	*oz.*	*lbs.*
1	Smooth Hulless	July	20	Sept.	7	2.6	0.275	8	12	2	2	63
2	Winnipeg No. 1	"	10	"	7	2.38	0.35	10	12	4	5	61.5
4	New Zealand	"	26	"	3	2.75	0.3	11	2	3	0.5	55.5
5	Chevalier	"	20	"	7	2.4	0.3	9	5	4	1.5	52.5
7	Winter (6-rowed)	"	26	"	11	2.5	0.15	8	13	3	8	47.5
8	Purple	"	10	"	3	2.4	0.18	7	5	2	15	65
9	Melon	"	20	Aug.	30	2.96	0.26	10	11	3	7	51
10	Del Norte	"	20	Sept.	7	2.2	0.2	4	14	1	7	62.5
11	Triumph	"	20	"	7	3.0	0.28	13	15	4	10	49.5
13	Kilma	"	13	"	7	2.3	0.22	9	3	3	2	55.5
14	Scotch Annat	"	20	"	7	2.55	0.37	10	6	2	14	53
15	Black	"	20	"	7	2.49	0.31	6	2	1	8	52.5
16	Palestine	"	26	"	7	2.65	0.3	9	8	2	11	55
17	Animate			"	7	2.6	0.3	8	9	2	12	52.5
18	Guymalye	"	16	"	7	2.0	0.275	6	9	2	6	64
19	Manchurian	"	22	"	11	3.11	0.38	18	11	5		54
20	Frick's	"	22	"	7	2.9	0.28	8	13	2	15	54
21	Spring (4-rowed)	"	22	"	7	2.85	0.25	11	13	3	14	49
22	Eufurt	"	26	"	7	2.9	0.4	17	8	3	15.5	55
23	Nepaul	"	10	Aug.	30	2.23	0.26	7		2	6	65
24	Winter (4-rowed)	"	13	Sept.	7	3.0	0.28	8	2	2	3	47
26	Sibley's Improved	"	20	"	3	2.85	0.26	10	2	3	5	46.5
27	Mansury			"	1	3.16	0.34					
28	Adams' Heavy			Aug.	30	2.5	0.28	10	6	1	2	52.5
29	Sibley's Pearl	"	20	Sept.	3	2.9	0.28	7	8	2	10	46.5
32	Berkley	"	20	"	7	2.65	0.27	5	4	1	12	52.5
33	Zeochrit	"	20	"	7	3.22	0.25	10	14	3	14	55
34	Perigerste	"	26	"	7	2.58	0.3	9	6	2	8	55
40	Algerian No. 2	"	26	"	3	2.7	0.25	11	2	2	10	48
41	" No. 3	"	20	"	7	2.5	0.12	6	14	2	9	47.5
42	Battledore	"	22	"	7	2.77	0.36	10	15	3	5	55.5
46	Himalaya	"	10	"	7	2.2	0.2	5	6	2	6	65
47	Carter's Prize	"	22	"	7	2.6	0.3	9	10	2	4	55
48	Goldthorpe	"	26	"	11	2.6	0.4	11	7	3	4	54.5

TABLE XI.—*Barley, 1898.*

This gives the results of the first year's trial of Professor Blount's collection of barleys. The varieties reported on in Tables IX and X were originally from Professor Blount, but the varieties reported on in the following table were grown from seed selected by him personally and furnished gratis to the Station. One row 10 feet long of each variety was planted. The rows were 20 inches apart.

No.	NAME	Date headed		Date ripe		Height	Length of heads	Yield of grain from 10 feet of row		Weight per bu.
						feet	*feet*	*lbs*	*oz.*	*lbs.*
1	Smooth Hulless	July	5	Aug.	17	2.43	0.3		11	65
2	Winnipeg No 1	"	2	"	17	2.35	0.36		10	65
3	" No. 2	"	5	"	16	2.78	0.34		14	50.5
4	New Zealand	"	12	"	23	2.58	0.29		12	52
5	Chevalier	"	19	"	31	2.45			8	51
6	Zealand	"	19	"	23	2.42	0.35			49.5
7	Winter (6-rowed)	"	23	"	31	1.96	0.2		12	48
8	Purple	"	5	"	17	2.38	0.26			
9	Melon	"	12	"	17	2.69	0.28		12	50.5
10	Del Norte	"	12	"	17	2.71	0.28	1		64.5
11	Triumph	"	12	"	17	2.59	0.27		12	47.5
12	Indian No. 4	"	12	"	11	2.79	0.34	1	3	48
13	Kilma	"	12	"	23	2.71	0.39	1	8	53
14	Scotch Annat	"	12	"	23	2.48	0.37		12	50
15	Black	"	12	"	17	2.48	0.26	1	3	47.5
16	Palestine	"	14	"	31	2.64	0.36	1		51
17	Animate	"	19	"	31	2.54	0.43		12	54
18	Guymalye	"	2	"	17	2.33	0.21		13	65
19	Manchurian	"	19	Sept.	6	2.67	0.36	1	4	50.5
20	Frick's	"	12	Aug.	17	2.58	0.31		15	50
21	Spring (4-rowed)	"	12	"	23	2.81	0.36	1		48
22	Eufurt	"	19	Sept.	6	2.77	0.39	1		49
23	Nepaul	"	12	Aug.	17	3.0	0.38		11	47
24	Winter (4-rowed)	"	12	"	17	3.26	0.4	1	5	47.5
25	Phoenix	"	5	"	17	2.35	0.38		12	63
26	Sibley's Improved	"	12	"	29	2.61	0.39			48.5
27	Mansury	"	12	"	17	2.84	0.39	1		43
28	Adams' Heavy	"	12	Sept.	2	2.71	0.3	1	3	50.5
29	Sibley's Pearl	"	12	Aug.	23	3.57	0.38	1		50
30	Sibley's Purple	"	19	Sept.	2	2.93	0.3	1	5	53
31	Wales	"	12	Aug.	23	2.71	0.31	1		50.5
32	Berkley	"	12	"	17	2.77	0.31		10	48.5
33	Zeochrit	"	12	"	23	3.13	0.3	1	3	53.5
34	Perigerste	"	19	Sept.	2	2.55	0.4	1	2	52.5
35	Black Grain	"	5	Aug.	17	2.28	0.18		15	66.5
40	Algerian No. 2	"	2	"	17	2.32	0.3	1	2	46
41	" No. 3	"	2	"	17	2.22	0.28		12	45.5
42	Battledore	"	14	"	27	2.54	0.17		11	55
46	Himalaya	"	2	"	17	2.45	0.26		13	65
47	Carter's Prize	"	14	Sept.	2	2.61	0.37			51.5
48	Goldthorpe	"	19	Aug.	23	2.72	0.26		12	50
49	. . . .	"	5	"	17	2.35	0.22		11	65.5
50	. . . .	"	14	Sept.	9	3.03	0.3		8	60

TABLE XII.—*Barley, 1899.*

This gives the results of the second year's trial of all the varieties reported in Table XI. One row 10 feet long of each variety was planted. The rows were 20 inches long.

No.	NAME	Date headed	Date ripe	Height	Length of heads	Yield of grain from 10 feet of row
				feet	*feet*	*oz.*
1*	Smooth Hulless					
2*	Winnipeg No. 1					
3*	" No. 2					
4*	New Zealand					
5*	Chevalier					
6*	Zealand		Sept. 8	2.2	0.3	5.5
8	Purple	July 28	" 28	2.4		16
10*	Del Norte	" 24	Aug. 30	2,2	0.2	4
11*	Triumph					
12*	Indian No. 4		Sept. 8	2.6	0.3	8.5
13	Kilma	" 20	Aug. 30	2.4	0.4	12.5
14	Scotch Annat	" 28	Sept. 8	2.5	0.37	15.5
15	Black	" 20	" 8	2.3	0.23	13
16	Palestine	" 24	Aug. 30	2.6	0.3	11
17	Animate	" 28	Sept. 8	2.4	0.35	16
18	Guymalye	" 14	Aug. 28	2.2	0.25	9
19	Manchurian	" 24	Sept. 8	2.7	0.35	19
20	Frick's	" 24	Aug. 30	2.4	0.3	8
21	Spring (4-rowed)	" 24	" 30	2.7	0.25	9.5
22	Eufurt	" 24	" 30	2.7	0.4	16
23	Nepaul	" 24	Sept. 8	2.5	0.3	12
24	Winter (4-rowed)	" 20	Aug. 28	3.2		18.5
25	Phoenix	" 14	" 28	2.6		12.5
26	Sibley's Improved	" 24	Sept. 8	2.4	0.23	15.5
27	Mansury	" 20	Aug. 28	2.8	0.35	12
28	Adams' Heavy	" 24	" 30	2.5	0.3	10.5
29	Sibley's Pearl	" 24	Sept. 8	2.3	0.33	10
30	" Purple	" 28	" 8	2.25	0.35	8
31	Wales	" 24	" 8	2.6	0.27	8
32	Berkley	" 24	" 8	2.6	0.33	9.5
33	Zeochrit	" 24	Aug. 30	2.9	0.2	12
34	Perigerste	" 24	Sept. 8	2.7	0.33	13.5
35	Black Grain	" 20	" 8	2.45	0.2	14
40	Algerian No. 2	" 20	Aug. 30	2.4	0.25	12
41	" No. 3	" 14	" 30	2.2	0.2	4.5
42	Battledore	" 24	Sept. 8	2.55	0.33	2.2
46	Himalaya	" 14	Aug. 19	2.3		7.5
47	Carter's Prize	" 24	" 30	2.8	0.35	16.5
48	Goldthorpe	" 24	" 30	2.6	0.25	17.5
49		" 14	" 19	2.6	0.2	10
50		" 14	" 19	2.9	0.2	13.5

*Injured by gophers.

TABLE XIII.—*Wheat, 1896.*

This gives the results from seed obtained from different sources. By using the New Mexico number reference may be made to Table I and the results of the same variety, grown from New Mexico seed, may be obtained. One row 50 feet long of each variety was planted The rows were 18 inches apart.

NAME	New Mexico No.	Source of seed	Date headed	Date ripe	Height	Length of heads	Yield of straw and grain from 50 feet of row		Yield of grain from 50 feet of row	
					ft.	*ft.*	*lbs.*	*oz*	*lbs.*	*oz*
Amethyst		Laramie	Aug. 8	Sept. 16	4.3	0.38	11	4	2	9
"		Nevada	July 31	" 15	3.7	0.3	10	1	3	1
Australian Club	22	Laramie	" 25	" 14	3.8	0.35	10	0	2	10
" "		Nevada	" 27	" 15	3.5	0.3	9	14	2	14.5
Bearded Oregon		Laramie	Aug. 8	" 16	4.0	0.35	16	10	3	6
Beryl	120	Nevada	July 27	" 14	3.5	0.26	10	2	3	2
Black Bearded Centennial		Laramie	Aug 8	" 18	5.0	0.3	16	15	4	4
Blount's No. 16	16	"	" 8	" 16	4.0	0.3				
Blue Stem		"		Oct. 8	4.0	0.35	11	7	2	2
" "		Nevada		Sept. 15	4 2	0.3	12	3	2	10
Chili	26	Laramie	" 8	" 16	4.3	0.36	13	15	2	7
"		Nevada	July 27	" 15	3.7	0.3	12	0	2	13
Dallas	100	"		" 15	3.6	0.34	10	9	2	10
Defiance	8	Laramie	Aug. 8	" 16	4.1	0.35	11	9	2	14
Egyptian Flint		Nevada	July 23	" 15	3.5	0.22	10	13	4	2
Gypsum		"		" 15	3.8	0.33	10	8	3	2
Henson		"	" 27	" 15	3.26	0.18	12	1	3	7
Holbein's Improved		"	" 27	" 15	3.5	0.3	9	7	2	13
Improved Fife		Laramie	Aug. 8	" 13	3.8	0.36	6	7	2	5
" "		Colorado		" 18	3.8	0.35				
" "		Nevada		" 15	3.6	0.3	10	4	2	7
Judkin	19	"	July 29	" 15	3.65	0.36	10	3	2	10
Missogen		"		" 15	3.25	0.18	8	11	3	0
Niagara	290	Laramie	Aug. 8	" 16	4.3	0.45	14	6	1	13
"		Nevada	July 27	" 15	3.6	0.3	10	11	3	5
Norfolk Red No. 1		Australia	" 29	" 7	3.95	0.3	1	5		10
Northcote Amber	399	Nevada		" 12	3.5	0.33				
Nox		Laramie	Aug. 8		4.3	0.37	13	3	3	0
"		Nevada	" 6	" 14	3.9	0.35	10	15	3	0
Ontario		"	July 27	" 15	4.1	0.20	11	1	3	0
Petali		"	" 25	" 14	3.1	0.25	9	11	3	8
Polish		Laramie	Aug. 8	" 6	4.5	0.55	14	8	4	3
"		Nevada	July 27	" 15	3.55	0.35	9	4	3	0
Pride of America		Laramie	" 25		4.5	0.25	18	10	5	3
Pringle's Champion		Nevada	" 29	" 15	3.9	0.33	13	7	4	5
Red Clawson	112	Canada								
Red Fern		Nevada		" 15	3.9	0.32	13	4	4	2
Red Oregon Club		"	" 27	" 15	3.26	0.25	9	9	2	7
Rio Grande	17	"	" 29	" 14	3.6	0.35	13	3	1	7.5
Ruby	58	"		" 18	4.0	0.34	9	6	1	13
Russian Hard	509	"	" 27	" 14	3.4	0.21	11	1	3	12
Sardius	118	"	" 27	" 14	3.5	0.33	8	15	1	12
Saskatchewan		"		" 15	4.0	0.35	12	7	3	1
" Fife		Laramie	Aug. 10	Oct. 6	4.1	0.43	14	2	3	2
Scotch Fife		"	" 8	Sept. 14	4.3	0.38	12	2	2	14
Scotch of Scotch		"	July 20	" 18	3.6	0.30	8	0	1	9
Seven Head		"	" 27	" 16	4.4	0.25	12	4	4	2
Velvet Chaff	54	Colorado	Aug. 8	" 14	4.0	0.38	10	12	2	2
Winnipeg Russian		Nevada	July 27	" 15	3.5	0.35	11	7	2	4
White Australian		"	" 27	" 15	3.5	0.28	11	15	3	15
White Russian		Laramie	Aug. 8	Oct. 6	3.9	0.45	9	10	1	7
White Touse		"	" 8	Sept. 16	4.35	0.35	19	0	5	7
Whittington		Nevada	July 29	" 14	3.2	0.37	7	14	2	1

TABLE XIV.—*Oats, 1896*.

This gives the results from seed obtained from different sources. By using the New Mexico number reference may be made to Table V and the results of the same variety, grown from New Mexico seed, may be obtained. One row 50 feet long of each variety was planted. The rows were 18 inches apart.

NAME	New Mexico No.	Source of seed	Date headed	Date ripe	Height	Length of heads	Yield of straw and grain from 50 feet of row		Yield of grain from 50 feet of row		Weight per bu.
					ft.	*ft.*	*lbs.*	*oz.*	*lbs.*	*oz.*	*lbs.*
Baltic White		Colorado	July 20	Sept. 8	4.4	0.75	13	6	4	12	41
Bavarian		Nevada	" 25	" 17	4.3	0.95	11	13	5	2	38
Black Diamond		Ontario	Aug. 7								
Black Russian		Laramie	July 25	" 8	3.7	0.75	15	2	3	14	37
Bonanza		"	" 25		4.5	1.15					38
Chinese Hulless		"	" 13	" 4	3.25	0.65	10	2	2	13	
Clydesdale		Nevada	" 23	" 8	4.6	1.0	14	3	4	10	44
Danebrog		"	" 25	" 17	4.0	0.85	15	5	4	15	39
Danish Island		"	" 13	" 2	3.9	0.75	12	8	4	14.5	43
Early Archangel		Laramie	" 23	" 17	3.8	0.85	11	5	3	9	40
Excelsior		Nevada	" 25	" 17	4.0	0.75	14	10	4	14	40
Golden Giant		"	" 29	" 22	4.2	1.1	10	0	1	15	
" " Side		Laramie	" 27	" 22	4.5	1.1	12	6	1	7	37
Hallet's Pedigree		Nevada	" 13	" 1	3.5	0.7	11	2	4	6	43
Highbred		"	" 25	" 17	4.3	0.9	15	7	4	7	
Hopetown	46	"	" 23	" 8	4.5	0.9	12	10	4	1	43
Hulless		"	" 13	" 8	4.5	1.0	16	3	4	0	42
Illinois		"	" 25	" 30	4.85	0.85	10	15	2	5	38
Lincoln		Colorado	" 20	" 8	4.3	0.75	15	12	5	3	41
"		Nevada	" 20	" 2	3.85	0.8	14	6	4	4	
"		Laramie	" 23	" 8	4.2	0.8	10	8	3	14	
Negro Wonder		Nevada	" 11	" 8	3.6	0.7	11	14	4	2	35
" "		Laramie	" 13	" 7	3.6	0.95	10	5	3	2	
New Danish Island		"	" 23	" 17	4.0	0.85	9	14	3	7	
New Zealand	13	Nevada	" 25	" 17	4.2	0.8	12	4	4	9	
Poland White		"	" 20	" 1	3.7	0.7	11	2	5	1	39
Pringle's No. 6	8	"	" 20	" 17	4.0	0.65	10	0	4	3	40
Race Horse		Laramie	" 13	" 5	4.0	0.9	10	5	2	11	
Siberian		Nevada	" 20	" 8	4.4	0.9	12	14	4	2	
Silesian	49	"	" 11	Aug. 25	3.5	0.6	8	15	3	6	
Scelician		Colorado	" 23	Sept. 17	3.9	0.75	14	11	4	7	
South Carolina		Nevada	" 13	" 8	3.9	0.7	14	14	5	10	39
Surprise		Laramie	" 13	" 4	4.0	0.85	10	4	3	9	42
White Dutch		Nevada	" 23	" 17	4.3	0.95	11	10	2	11	41
White Snohomish		Oregon	" 13	" 8	4.2	1.0	14	1	5	3	43
" Wonder		Laramie	" 13	" 15	4.0	1.0	11	6	3	11	42
Yellow French		Colorado	" 29	Oct. 7	3.8	1.1	12	8	2	8	41
" German		"	" 17	Sept. 17	4.0	0.7	12	9	4	11	40
Zoanette Black		Nevada	" 20	Oct. 17	3.9	0.7	16	5	5	0	37

TABLE XV.—*Barley, 1896.*

This gives the results from seed obtained from different sources. By using the New Mexico number reference may be made to Table IX and the results of the same variety, grown from New Mexico seed, may be obtained. One row 50 feet long of each variety was planted. The rows were 18 inches apart.

NAME	New Mexico No.	Source of seed	Date headed	Date ripe	Height	Length of heads	Yield of straw and grain from 50 feet of row		Yield of grain from 50 feet of row		Weight per bu.
					ft.	*ft.*	*lbs*	*oz.*	*lbs.*	*oz.*	*lbs.*
Bastian's Six-Rowed		Nevada	July 17	Aug. 23	2.75	0.17	7	12	3	2	54
Black	15	"	" 11	" 24	2.8	0.25	10	11	4	5	
"		Laramie	" 6	" 25	2.7	0.3	11	11	5	1	
California		Colorado	" 1	" 31	2 3	0.2	9	6	4	15	47
Chevalier	5	Nevada	" 11	" 31	2.7	0.37	13	14	6	1	
"		Colorado	" 20	" 27	3.25	0.3	13	15	4	6	
"		Laramie	" 20	" 31	3.6	0.33	16	3	5	11	
Excelsior		Nevada	" 6	" 15	2.65	0.25	5	7	2	6	50.5
Frick's		"	" 13	" 23	3.1	0.3	10	11	4	5	
Frick's Drought Proof		"	" 11	" 31	2.61	0.26	5	9	4	5	50
Golden Grain		"	" 20	Sept. 7	2.95	0.35	14	1	5	15	53
Goldthorpe		"	" 23	" 7	3.4	0.4	13	5	5	2	
Guymale		Laramie	" 6	" 7	2.4	0.27	10	5	4	7	64
Guy Malaya		Nevada	" 23	Aug. 31	3.1	0.27	8	13	3	7	60
Guy Mayle		"	" 11	" 17	2.0	0.2	8	2	4	1	63
Highland Chief	49	"	" 20	Sept. 9	3.25	0.35	14	6	5	3	
" "		Laramie	" 23	" 7	3.3	0.36	13	6	3	15	
Italian		Nevada	" 20	Aug. 24	3.0	0.28	12	5	9	5	50
Manchurian		"	" 11	" 23	3.2	0.3	11	6	5	6	48.5
Manshury		Laramie	" 11	" 27	2.9	0.3	13	3	5	12	
"		Nevada	" 11	" 24	3.4	0.35	11	7	5	0	
Nepaul	23	Laramie	" 11	" 31	2.6	0.22	11	6	4	8	
New Black		"	" 6	" 25	2.6	0.17	12	1	4	15	63 5
New White Hulless		Nevada	" 6	" 24	2.7	0.25	10	7	4	0	56
New Zealand		Colorado	" 17	Sept. 7	3.7	0.4	12	11	5	4	54 5
Oderbencker		Nevada	" 11	Aug. 24	3.0	0.27	7	9	3	1.5	54
Purple		"	" 11	" 17	2.5	0.2	8	14	2	13	
Six-Rowed		"	" 20	" 31	2.8	0.15	12	1	6	2	48
"		Laramie	" 6	" 31	2.5	0.2	11	1	5	6	
Smooth Hulless		Nevada	" 11	" 17	2.9	0.26	9	9	3	2	64
Two-Rowed		"	" 23	Sept 7	3.1	0.35	12	7	4	14	53
"		Laramie	" 25	" 7	3.2	0.4	13	15	4	1	
Vermont Champion		"	" 11	Aug. 27	3.26	0.28	16	4	5	10	56
Winnipeg		Nevada	" 11	" 27	2.7	0.3	8	10	2	15	63
Winter		Oregon	" 25	Sept. 17	3.26	0.18					
Winter Six-Rowed		Nevada	" 11	Aug. 31	2.61	0.15	13	7	6	10	

The Cryptogams of Wyoming.

A Preliminary Report upon those Species which have been Secured to Date in the Botanical Survey of the State.

BY

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LARAMIE, WYOMING,
1900.

Cryptogams of Wyoming.

AVEN NELSON.

The first Report on the Flora of Wyoming, publish-in May, 1896, had scarcely more than a reference to the cryptogamic plants of the state. That report represented only two seasons' field-work, devoted almost exclusively to the flowering plants, of which 1,295 species were enumerated. Since it was issued, four seasons' field-work has been done, increasing so materially our knowledge of the plants of the state that said report most inadequately represents what is known of our flora. This is true both of the seed and the spore plants, but especially of the latter. Never in the history of Rocky Mountain botany has there been such activity as during the last half decade. Field-work has been prosecuted by many collectors, from Montana to New Mexico. Not less active have those workers been who are devoting themselves to herbarium work and to bibliographical and nomenclatural studies. As a result of all this activity our publications are soon outgrown and new editions are called for to represent the ever increasing collections and the changes in nomenclature which recent studies seem to indicate as essential to justice and permanency.

The representation of Wyoming plants in the Rocky Mountain Herbarium, which is being built up at this institution, has increased to such an extent, both in respect to the number of species and the localities represented, that nothing short of a new report will adequately represent its present status. Such a report may not be undertaken now as regards the seed plants but the still relatively short list of spore plants is herein presented. This annotated list, it is believed, will prove of interest and service to many.

Unless otherwise stated the specimens upon which this report is based were collected by the writer. With the exception of a few well authenticated species, none are reported unless represented by one or more specimens in this collection (The Rocky Mountain Herbarium). Among the collections included of which we have no specimens are the fungi secured by Mr. David Griffiths, in company with Messrs. T. A. Williams and L. W. Carter, in northeastern Wyoming, the list of which was published in Bull. Torr. Bot. Club, Vol. 26 (1899), some lichens collected by Robert Reuleux in Yellowstone Park, determined and published by Dr. Stezenberger (Erythea 3:30), and some miscellaneous species from Hayden's Sixth Annual Report (1873) are also included.

For the determination of the species reported in this paper, I am indebted to a number of specialists whose names occur in connection with the groups represented. The thanks of the writer is extended to each of them and to Mr. Elias Nelson, M. A., who has greatly assisted in the preparation of the manuscript.

THE ALGAE.

No special effort has been made to collect the algae. Much material selected for use in the class-room has been located generically only. The list of algae if ever enumerated will be a long one. The waters of the state represent the very extremes of temperature and of salt content. I have no doubt that many undescribed species exist in the waters of our numerous alkali lakes. The following list represents the genera that have been noted in the material used in the botanical courses. The specific determinations (where given) are by Prof. DeAlton Saunders, except in Chara, which is by Dr. T. F. Allen.

CLASS—DIATOMEAE.

Diatoms abound in all of our waters. Navicula, Synedra, Diatoma, Pinnularia, etc., are genera well represented. The specific dedeterminations would require much time.

CLASS—CYANOPHYCEAE.

NOSTOCALES.

NOSTOCACEAE

Nostoc commune Vauch.

Very plentiful in small pools on ledges of rock: Telephone Canon, Albany Co., April 28, 1897, no. 2854.

Anabaena

This genus is not well represented though one or more species occur in spring pools.

OSCILLARIALES.

In this order, the family Oscillariaceae is represented by the following genera; Oscilllaria, Lyngbya and Phormidium. Some species of Oscillaria met with in laboratory material are probably, O. Nigra Vauch., O. Froelichii Kuetz. var., O. gracillima Kuetz. and O. tenerrima Kuetz.

CLASS—CHLOROPHYCEAE.

PROTOCOCCALES.

This order is represented in the family Protococcaceae by the genera, Protococcus and Scenedesmus, and in Hydrodictyaceae by Pediastrum.

SIPHONALES.

The genus Vaucheria, family Vaucheriaceae, is represented by a species which is probably V. geminata (Vauch.) DC.

CONJUGATALES.

DESMIDIACEAE.

Closterium acerosum (Schrank) Ehrh.

Laramie, Nov. 3, 1898, no. 5360.

Many other species in this genus occur in abundance.

Cosmarium sp.

Plants belonging to this genus have been observed at several times.

MESOCARPACEAE.

Mougeotia scalaris Hass.

Big Wind River, Fremont Co., Aug. 10, 1894, no. 5375.

ZYGNEMACEAE.

Zygnema insignis Kuetz.

Laramie, Albany Co., Oct. 13, 1896 no. 2810; Nov. 7, 1898, no. 5373.

Zygnema leiospermum De By.

Laramie, Albany Co., Nov. 3, 1898, no. 5368.

Zygnema spp.

Species of this genus are very common.

Spirogyra orbicularis (Hass.) Kuetz.

Common in the creek: Nez Perces Creek, Yellowstone National Park, July 30, 1899, no. 6239.

Spirogyra varians (Hass.) Kuetz.

City Springs, Laramie, Albany Co., Apr. 9, 1898, no. 4303.

Spirogyra spp.

This genus is well represented. A considerable number of different forms have been observed.

CONFERVOIDALES.

ULOTHRICHACEAE.

Ulothrix spp.

Several forms belonging here have been observed.

Conferva abbreviata Rab.

Laramie, Albany Co., Oct. 24, 1896, no. 2819; City Springs, Nov. 3, 1898, no. 5369.

Conferva bombycina Ag.

Laramie, Albany Co., Nov. 3, 1898, no. 5364.

CLADOPHORACEAE.

Cladophora fracta Kuetz.

In alkali ponds and lakes; Laramie, Albany Co., Oct. 11, 1896, no. 2811; Nov. 3, 1898, no. 5363.

Cladophora fracta horrida Kuetz.

Laramie, Albany Co., Nov. 3, 1898, no. 5361.

Cladophora glomerata Kuetz.

Fish Hatchery, Albany Co., Oct. 4, 1896, no. 2808; Laramie Oct. 11, no. 2813.

CHAETOPHORACEAE.

Of this family the following have been observed: a species of Chaetophora, probably C. longipila Kuetz., found on submerged grass caulms in a meadow; two species of Stigeoclonium, probably S. tenue Kuetz. and S. fastigiatum Kuetz.; a species of Draparnaldia.

OEDOGONIACEAE.

Plants belonging to the genus Oedogonium have been collected a few times at Laramie.

CLASS—CHAREAE.

CHARALES.

CHARACEAE.

Chara contraria A. Br.

In a pond: Mammoth Hot Springs, Yellowstone National Park, July 20, 1899, no. 6022.

Chara foetida A. Br.

Very frequent throughout the state in stagnant pools: Wind River, Fremont Co., Aug. 9, 1894, no. 796; Sundance Creek, Crook Co., July 6, 1896, no. 2208; Iron Mt., Laramie Co., Aug. 26, no. 2738; Platte River, Laramie Co., Aug. 27, no. 2767; Laramie, Albany Co., Sept. 7, no. 2780.

Chara fragilis Desv.

In the warm water of the creek: Nez Perces Creek, Yellowstone National Park, July 30, 1899, no. 6238.

CLASS—PHAEOPHYCEAE.

PHAEOSPORALES.

SYNGENETICACEAE.

Hydrurus foetidus (Vell.) Kirch.

Fish Hatchery, Albany Co., Oct. 4, 1896, no. 2807.

Hydrurus foetidus occidentalis Harv.

Fish Hatchery, Albany Co., Nov. 29, 1896, no. 2836.

CLASS—RHODOPHYCEAE.

This class is represented by one species, Batrachospermum gelatinosum (L.) A. F. Woods (?), of the family Batrachospermaceae, order Nemalionales.

THE MOSSES.*

CLASS—HEPATICAE.

JUNGERMANNIALES.

JUNGERMANIACEAE.

Chiloscyphus polyanthos (L) Corda.

Submerged in mountain brooks and alpine lakes: Centennial Hills, Albany Co., Aug. 20, 1896, no. 2706; La Plata Mines, Aug. 28, 1898, no. 5230.

Jungermannia cordifolia A. W. Evans.

Wolf Creek Sheridan Co., July 12, 1896, no. 2321; Centennial Hills Albany Co., Aug. 20, 1896, no. 2705; La Plata Mines, Albany Co., Aug. 29, 1898, no. 5247.

MARCHANTIALES.

MARCHANTIACEAE.

Marchantia polymorpha L.

On moist ground in woods: Head of Green River, Uinta Co., Aug. 25, 1894, no. 1051; Centennial Valley, Albany Co., Aug. 18, 1895, no. 1748; Wolf Creek, Sheridan Co., July 12, 1896, no. 2318.

Preissia hemisphaerica (L) Cogn.

On the wet, shaded banks of the lake: Lewis Lake, Yellowstone National Park, Aug. 21, 1899, no. 6601.

Conocephalus conica (L.) Dumort.

Lower Firehole Basin, Yellowstone National Park, Aug., 1872—Coulter.

CLASS—MUSCI.

SPHAGNALES.

SPHAGNACEAE.

Sphagnum acutifolium Ehrh.

Shoshone Lakes, Yellowstone National Park, Sept., 1872—Coulter.

Sphagnum fimbriatum Wils.

In Great beds on wet bottoms; Obsidian Creek, Yellowstone National Park, July 24, 1899, no. 6118; Sylvan Geysers, July 26, no. 6181.

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*I wish to acknowledge the painstaking care in the determination of the Mosses by Prof. John M. Holzinger of the State Normal School at Winona, Minn. Some of the groups were submitted by him to other specialists, viz., Dr. Cardot, Dr. True and others; the Hepaticae by Dr. Underwood.

BRYALES.

POLYTRICHACEAE.

Pogonatum alpinum Roehl.

Battle Lake Mt., Carbon Co., Aug. 17, 1897, no. 4225; La Plata Mines, Albany Co., Aug. 25, 1898, no. 5170, Aug. 28, no. 5233.

Polytrichum commune L.

Yellowstone National Park: Norris, July 25, no. 6144; Sylvan Geysers, July 26, no. 6182.

Polytrichum gracile Menz.

Sylvan Geysers, Yellowstone National Park, July 26, 1899, no. 6175.

Polytrichum Jenseni Hagen.

Beaver Lake, Yellowstone National Park, July 24, 1899, no. 6131.

Polytrichum juniperinum Willd.

Sundance Mt., Crook Co., July 3, 1896, no. 2180: Yellowstone National Park; Glen Creek, June 30, 1899, no. 5596; Yancey's July 17, no. 5935.

Polytrichum juniperinum alpinum Schimp.

La Plata Mines, Albany Co., Aug. 24, 1895, no. 1830.

Polytrichum piliferum Schreb.

La Plata Mines, Albany Co., Aug. 21, 1895, no. 1768, Aug. 28, 1898, no. 5231; Willow Creek, May 22, 1897, no. 2919; Lewis River, Yellowstone National Park, Aug. 9, 1899, no. 6369.

Polytrichum sexangulare Floerke.

La Plata Mines Albany Co., Aug. 28, 1898, no. 5232.

Polytrichum strictum Menz.

Little Goose Creek, Sheridan Co., July 16, 1896, nos. 2361 in part, 2363; Wood's Creek, Albany Co., Aug. 11 1896 no. 2071.

MNIACEAE.

Mnium affine Bland.

Centennial Valley Albany Co., Aug. 18, 1896, no. 2670.

Mnium affine rugicum Bruch & Schimp.

Snake River, Yellowstone National Park, Aug. 12, 1899, no. 6426.

Mnium cuspidatum Hedw.

Little Goose Creek, Sheridan Co., July 16, 1896, nos. 2366, 2376.

Mnium cuspidatum tenellum Kindb.

Laramie Hills, Albany Co., May 21, 1898 no. 4308.

Mnium hornum L.
La Plata Mines, Albany Co., Aug. 25, 1898, no. 5171.

Mnium serratum Laich.
La Plata Mines, Albany Co., Aug. 25, no. 5176.

Mnium subglobosum Bruch & Schimp.
Centennial Valley, Albany Co., Aug. 19, 1895, no. 1744; Centennial Hills, Aug. 20, 1896, no. 2702.

Timmia Austriaca Hedw.
Laramie Peak, Albany Co., Aug. 8, 1895, no. 1645; Wolf Creek, Sheridan Co., July 12, 1896, no. 2324; Little Goose Creek, July 16, no. 2364 in part.

Timmia Austriaca brevifolia Ren. & Card.
Cooper Hill, Albany Co., Aug. 22, 1897, no. 4265; La Plata Mines, Aug. 25, 1898, no. 5174; Tower Falls, Yellowstone National Park, July 16, 1899, no. 5913.

Aulacomnium androgynum Schwaegr.
On logs in deep woods: Yellowstone National Park; Obsidian Creek, July 24, 1899, no. 6099; Snake River, Aug. 12, no. 6429.

Aulacomnium palustre Schwaegr.
Common: Lincoln Gulch, Aug. 12, 1896, nos. 2601, 2618: Sheridan Co.; Dome Lake, July 16, 1896, no. 2417; Little Goose Creek, no. 2364 in part: Yellowstone National Park; Druid Peak, July 12, 1899, no. 5795; Nez Perces, Creek, July 29, no. 6232.

Aulacomnium papillosum Lesq. & James.
Centennial Valley, Albany Co., Aug. 19, 1895, no. 1746 in part.

MEESIACEAE.

Amblyodon dealbatus Beauv
Ferris Mts., Carbon Co., July 25, 1898 no. 4976 in part.

BARTRAMIACEAE.

Bartramia ithyphylla Bird.
La Plata Mines, Albany Co., Aug. 25, 1898, no. 5177.

Philonotis fontana Brid.
Centennial Valley, Albany Co., Aug. 18, 1895, no. 1756; Wolf Creek, Sheridan Co., July 12, 1896, no. 2317; Wood's Creek, Albany Co., Aug. 11, 1896 no. 2588; Obsidian Creek, Yellowstone National Park, July 22, 1899, no. 6062; Lewis River, Aug. 9, no. 6381.

Philonotis fontana alpina Brid.
Obsidian Creek, Yellowstone National Park, July 24, 1899, no. 6110.

Philonotis Mohriana Lesq. & James.
Battle Lake, Mt., Carbon Co., Aug. 17, 1897, no. 4202 in part.

BRYACEAE.

Bryum angustirete Kindb.
Cokeville, Uinta Co., June 11, 1898, no. 4656.

Bryum argentium L.
Laramie, Albany Co., July 29, 1897, no. 3454.

Bryum caespiticium L.
Wood's Creek, Albany Co., Aug. 9, 1897, no. 3481; Ft. Bridger, Uinta Co., June 8, 1898, no. 4595; Yellowstone Lake, Aug. 23, 1899, no. 6640.

Bryum cirrhatum Hoppe & Hornsch.
La Plata Mines, Albany Co., Aug. 28, 1898, no. 5235; Cummins, Albany Co., July 30, 1895, no. 1538 in part.

Bryum crassirameum Ren. & Card.
Ferr's Mts., Carbon Co., July 25, 1898, no. 4977.

Bryum inclinatum Bruch & Schimp.
Laramie Hills, Albany Co., June 13, 1896, no. 1928.

Bryum intermedium Brid.
Centennial Valley, Albany Co., June 18, 1895, no. 1263.

Bryum Oreganum Sulliv.
Centennial Hills, Albany Co., Aug. 20, 1896, nos. 2708, 2707 in part; Dome Lake, Sheridan Co., July 16, 1896, no. 2416 in part.

Bryum pendulum Schimp.
Little Goose Creek, Sheridan Co., July 16, 1896, no. 2362; Buffalo, Johnson Co., July 25, 1896, no. 2505; Centennial Valley, Albany Co., Aug. 17, 1896, no. 2654.

Bryum pseudotriquetrium Schwaegr.
Centennial Valley, Albany Co., June 8, 1895, no. 1259.

Bryum torguescens Bruch & Schimp.
On damp ground in woods; Druid Peak, Yellowstone National Park, July 12, 1899, no. 5801.

Bryum turbinatum latifolium Schimp.
Ferris Mt., Carbon Co., July 25, 1898, no. 4978.

Leptobryum pyriforme Schimp.

Centennial Valley, Albany Co., Aug. 18, 1895, nos. 1717, 1723 in part; Centennial Hills, Albany Co., Aug. 20, 1896, no. 2707 in part; Wood's Creek, Aug. 11, no. 2589 in part; Yellowstone Lake, Aug. 11, no. 2589 in part; Yellowstone Lake, Aug. 24, 1899, no. 6645.

FUNARIACEAE.

Funaria hygrometrica Hedw.

Sheridan Co.: Wolf Creek, July 12, 1896, no. 2322a; Dome Lake, July 16, no. 2322.

WEBERACEAE.

Webera albicans Schimp.

Centennial Valley, Albany Co., June 9, 1895, no. 1285; North Vermillion Creek, Sweetwater Co., July 17, 1897, no. 3576; Evanston, Uinta Co., July 27, 1897, no. 4128 in part; Battle Lake, Carbon Co., Aug. 16, 1897, no. 4180; Hat Six Falls, Natrona Co., Aug 7, 1898, no. 5035; La Plata Mines, Albany Co., Aug. 25, 1898, no. 5248.

Webera cruda Schimp.

Centennial Valley, Albany Co., Aug. 17, 1896, no. 2657.

Webera nutans Hedw.

Sundance Mt., Crook Co., July 3, 1896, no. 2173 in part; Lincoln Gulch, Albany Co., Aug. 13, 1896, no. 2629; La Plata Mines, Aug. 25, 1898, no. 5175; Yellowstone National Park; Trout Lake, July 14, 1899, no. 5846; Beaver Lake, July 24, no. 6124; Upper Geyser Basin, July 31, no. 6259.

TORTULACEAE.

Barbula amplexa Lesq.

La Plata Mines, Albany Co., Aug. 28, 1898, no. 5234.

Barbula mucronifolia Bruch & Schimp.

Cooper Hill, Albany Co., Aug. 22, 1897, no. 4995; Cummins, July 30, 1895, no. 1538 in part.

Barbula Muelleri Bruch & Schimp.

Sundance Mt., Crook Co., July 3, 1896, no. 2181; Hat Six Falls, Natrona Co., Aug. 7, 1898, no. 5034.

Barbula ruralis Hedw.

Near Rock Springs, Sweetwater Co., July 25, 1897, no. 3598.

Desmatodon Porteri James.

Cummins, Albany Co., July 30, 1895, no. 1538 in part.

Leptotrichum flexicaule Hampe.
Tower Falls, Yellowstone National Park, July 16, 1899, no. 5912.

Didymodon rubellus Bruch & Schimp.
Head of Pole Creek, Albany Co., July 22, 1897, no. 3438.

DICRANACEAE.

Gymnostomum curvirostrum Hedw.
South Butte, Sweetwater Co., July 13, 1897, no. 3549.

Dicranoweisia cirrhata Lindb.
On rocks; Specimen Ridge, Yellowstone National Park, July 15, 1899, no. 5892.

Dicranoweisia crispula Lindb.
Sheep Mt., Albany Co., July 3, 1897, no. 3312.

Dichodontium Olympicum Ren. & Card.
La Plata Mines, Albany Co., Aug. 25, 1898, no. 5178.

Dicranum Bonjeani De Not.
On dry shaded ground; Beaver Lake, Yellowstone National Park, July 24, 1899, no. 6125.

Dicranum neglectum Jur.
On cliffs; Yancey's Yellowstone National Park, July 17, 1899, no. 5936.

Ceratodon purpureus Brid.
Sheridan Experiment Farm, Sheridan Co., July, 1894, no. 1211 in part; Sundance Mt., Crook Co., July 3, 1896, no. 2168; Wood's Creek, Albany Co., Aug. 11, 1896, no. 2589 in part.

Distichium capillaceum Bruch & Schimp.
Wolf Creek Canon, Sheridan Co., July 12, 1896, nos. 2298, 2307, 2315; Buffalo, Johnson Co., July 25, no. 2507 in part; Laramie Hills, Albany Co., May 31, 1898, no. 4307; La Plata Mines, Aug. 25, no. 5173; Druid Peak, Yellowstone National Park, July 12, 1899, no. 5803.

Distichium inclinatum Bruch & Schimp.
On rocks, Mammoth Hot Springs, Yellowstone National Park, July 20, 1899, no. 6026.

GRIMMIACEAE.

Racomitrium canescens Brid.
Nez Perces Creek, Yellowstone National Park, July 29, 1899, no. 6210.

Racomitrium fasiculare Brid.
Jackson's Lake, Uinta Co., Sept., 1872—Coulter.

Grimmia alpestris Schleich.
Centennial Hills, Albany Co., Aug. 20, 1896, no. 2699.

Grimmia apocarpa Hedw.
Dome Lake, Sheridan Co., July 16, 1896, no. 2416 in part.

Grimmia calyptrata Hook.
Willow Creek, Albany Co., May 22, 1897, no. 2917.

Grimmia commutata Hueben.
La Plata Mines, Albany Co., Aug. 29, 1898, no. 5243.

Grimmia conferta Funck.
Yellowstone Valley, Aug. 1872—Coulter.

Grimmia Scouleri Meull.
Yellowstone Valley, Aug., 1872—Coulter.

Scouleria aquatica Hook.
Dome Lake, Sheridan Co., July 16, 1986, no. 2416 in part.

Encalypta ciliata Hedw.
Sundance Mt., Crook Co., July 3, 1896, no. 2173 in part.

Encalypta rhabdocarpa Schwaegr.
Little Goose Creek, Sheridan Co., July 16, 1896, no. 2361 in part; Telephone Canon, Albany Co., Apr. 28, 1897, no. 2855.

Orthotrichum cupulatum Hoffm. ?
Willow Creek, Albany Co., May 22, 1897, no. 2918.

Orthotrichum laevigatum Zett.
Druid Peak, Yellowstone National Park, July 2, 1899, no. 5791.

HYPNACEAE.

Pseudoleskea oligoclada Lindb.
Centennial Hills, Albany Co., Aug. 18, 1895, no. 1724.

Thuidium Blandovii (Web. & Mohr.) Bruch.
Centennial Valley, Albany Co., Aug. 19, 1895, no. 1746 in part. Centennial Hills, Aug. 20, 1896, no. 2700.

Leskia n. sp. (?)
Hat Six Falls, Natrona Co., Aug. 7, 1898, no. 5036.

Camptothecium aeneum (Nitt.) Lesq. & James.
Sundance Mt., Crook Co., July 3, 1896, no. 2166; Hat Six Falls, Natrona Co., Aug. 7, 1898, no. 5039; La Plata Mines, Albany Co., Aug. 30, 1898, no. 5265.

Camptothecium lutescens Bruch & Schimp.
On moist ground. Mammoth Hot Springs, Yellowstone National Park, July 21, 1899, no. 6041.

Brachythecium acutum Sulliv.
Centennial Valley, Albany Co., Aug. 17, 1895, no. 1698.

Brachythecium rivulare Bruch & Schimp.
Albany Co.: Laramie Peake, Aug. 7, 1895, no. 1622; Centennial Hills, Aug. 20, 1896, no. 2701; Laramie, Sept. 15, 1897, no. 4283.

Brachythecium salebrosum Bruch. & Schimp.
Wood's Creek, Albany Co., Aug. 9, 1897, no. 3480; The Thunderer Yellowstone National Park, July 13, 1899, no. 5812.

Brachythecium Utahense James.
Centennial Hills, Albany Co., Aug. 20, 1896, nos. 2712 2716.

Raphidostegium recurvans Lesq. & James.
Lincoln Gulch, Albany Co., Aug. 13, 1896, no. 2628.

Amblystegium filicinum Lindb. var.
Ferris Mts., Carbon Co., July 25, 1898, no. 4976 in part.

Amblystegium hygraphilum Schimp. (?)
In a bog; Yanceys' Yellowstone National Park, July 16, 1899, no. 5903.

Amblystegium Kochii Schimp.
Sundance Creek, Crook Co., July 7, 1896, no. 2233; Centennial Valley, Albany Co., Aug. 18, 1896, no. 2671.

Amblystegium porphyrrhizum Lindb.
On a moist, rotten log; Laramie Hills, Albany Co., June 13, 1896, no. 1929.

Amblystegium serpens Bruch & Schimp.
Ferris Mts., Carbon Co., July 25, 1898, no. 4979 in part.

Amblystegium varium Lindb.
Ferris Mts., Carbon Co., July 25, 1898, no. 4979 in part.

Hypnum aduncum Hedw
Cooper Hill, Albany Co., Aug. 22, 1897, no. 4266; Ft. Bridger, Uinta Co., June 9, 1898, no. 4609; Cokeville, June 11, no. 4624; La Plata Mines, Albany Co., Aug. 30, 1898, no. 5262; Obsidian Creek, Yellowstone National Park, July 24, 1899, no. 6106.

Hypnnm aduncum Kneiffii Schimp.
Little Laramie River, Albany Co., Sept. 14, 1896, no. 4294.

Hypnum arcticum Sommerf.
Centennial Hills, Albany Co., Aug. 20, 1896, no. 2704.

Hypnum callichroum Brid. (?)
Evanston, Uinta Co., July 27, 1897, no. 4128 in part.

Hypnum capillifolium Warnst.
Dome Lake, Sheridan Co., July 16, 1896, no. 2408; Wagon Hound Creek, Carbon Co., Aug. 21, 1897, no. 4262; Evanston, Uinta Co., Aug. 31, 1897, no. 4277.

Hypnum commutatum Hedw.
Union Pass, Fremont Co., Aug. 12, 1894, no. 1078.

Hypnum depressulum Muell.
Laramie, Hills, Albany Co., June 13, 1896, no. 1924; La Plata Mines, Aug. 25, 1898, no. 5172.

Hypnum filicinum L.
Green Mt., Crook Co., July 6, 1896, nos. 2221, 2222.

Hypnum fluitans L.
Snake River, Yellowstone National Park, Aug. 12, 1899, no. 6485.

Hypnum hispidulum Brid
Beaver Creek, Weston Co., July 30, 1896, no. 2563; Cooper Hill, Albany Co., Aug. 22, 1897, no. 4296.

Hypnum laetum Brid.
Yellowstone Valley, Aug. 23, 1872—Coulter.

Hypnum palustre Hedw.
Battle Lake Mt., Carbon Co., Aug. 17, 1897, no. 4202 in part.

Hypnum plicatile Lesq. & James.
Cummins, Albany Co., July 29, 1895, no. 1507.

Hypnum revolutum.
Head of Pole Creek, Albany Co., May 5, 1897, no. 2861.

Hypnum stellatum Schreb.
Beaver Creek, Weston Co., July 30, 1896, no. 2556.

Hypnum symmetricum Ren. & Card.
Dome Lake, Sheridan Co., July 16, 1896, no. 2416, no. 2416 in part.

Hypnum uncinatum Hedw.
La Plata Mines, Albany Co., Aug. 29, 1898, no. 5244; Tower Falls, Yellowstone National Park, July 16, 1899, no. 5911.

Limnobium (?) sp.
Hat Six Falls, Natrona Co., Aug. 7, 1898, no. 5038.

STEREODONTACEAE.

Hylocomium splendens Bruch & Schimp.

Wolf Creek Canon, Sheridan Co., July 12, 1896, no. 2306.

Plagiothecium Sullivantiae Schimp.

La Plata Mines, Albany Co., Aug. 29, 1898, no. 5242.

NECKERACEAE.

Climacium Americanum Brid.

Centennial Valley, Albany Co., Aug. 18, 1895, no. 1724.

Climacium dendroides Web. & Mohr.

Upper Canon of the Madison River, Aug., 1872—Coulter.

Fontinalis antipyretica Oregonensis Ren. & Card. (?)

Lincoln Gulch, Albany Co., Aug. 12, 1896, no. 2619.

Fontinalis Duriali Schimp.

North Vermillion Creek, Sweetwater Co., July 17, 1897, no. 3577

Fontinalis hypnoides Hartm.

Evanston, Uinta Co., May 29, 1897, no. 3004; Albany Co., Aug. 7, 1897.

Fontinalis Neo-Mexicana Sulliv. & Lesq.

Little Goose Creek, Sheridan Co., July 16, 1896, no. 2371; Buffalo, Johnson Co., July 25, 1896 no. 2506.

Fontinalis Neo-Mexicana Columbica Cardot.

In flowing water; Spring Creek Yellowstone National Park, Aug. 3, 1899.

Fontinalis nitida Lindb.

Moorcraft, Crook Co., July 8, 1896, no. 2248.

Hedwigia ciliata Ehrh.

Shoshone Lake, Yellowstone National Park, Sept., 1872—Coulter.

THE FUNGI.[*]

Dr. Underwood, in his recently published book, Moulds, Mildews and Mushrooms, gives a brief summary of the work that has been done upon the fungi in the different states and countries of North America. Of Wyoming he writes as follows: "Comparatively little has been done in the direction of local study of fungi in this state. Professor Aven Nelson has collected a few species in connection with his work on the higher flora of the state,[†] and Prof. T. A. Williams and David Griffiths have collected largely the parasitic fungi in connection with other work. Most of these collections are as yet unstudied." Little as has been done in this state we are not worse off than some of the other and much older states, some of which Dr. Underwood designates as *terrae incognitae*. With the publilation of the present list, we may at least say that a beginning has been made.

But it is only a beginning. A region of 100,000 square miles in extent, with a climate varying according to the conformation, the exposure and the altitude and latitude of the land represented gives a flora as varied as its topography. Unless the number of workers in this field is vastly increased it will be many years yet before the state is measureably well known.

The fungi parasitic upon the higher plants, especially upon the crop plants, are always the first to receive consideration. The smuts, the rusts and the mildews attract attention by reason of the disastrous effect that they produce in the garden, the orchard and the field. Those that are the most to be dreaded usually find their way into new territory in connection with the introduction of their nat-ral hosts. The remarkable immunity that this state has so far enjoyed is to be associated with the climatic conditions which are, in a measure, unfavorable to the development of the parasitic fungi. Those which are epithytic or infect the host plant through its external tissues are not particularly abundant in Wyoming. These need for their highest development a moist, warm climate. However, a number of species have adapted themselves even to the conditions that prevail on the arid plains as well as to those of the colder, moist mountain regions. These are of interest since they show that even our climatic conditions must not be expected to secure for our crops complete immunity. That class of ***endoparasites***, represented by the smuts, which pass their life history, in large part, wholly within the tissues of the host may become as troublesome here as elsewhere.

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[*] For the determination of the parasitic fungi we are indebted to Dr. J. B. Ellis of Newfield N. J., while the few species of woody and fleshy forms were examined by Dr. L. M. Underwood and Dr. C. H. Peck, respectively.

[†] The statement must be based upon and have reference to the exceedingly short list published in Bulletin 28 of this Station, the report referred to above.

THE FLESHY FUNGI.

Mushrooms, toadstools, etc., seem to be very abundant in the state but their study is attended by almost insurmountable difficulties. Only collectors realize how hard it is to so dry specimens as to preserve them and yet leave them in condition for study. Such plants should be studied in the fresh state, but this is also nearly precluded with us. They are a product found almost exclusively in the woods and as such collecting grounds are from 30 to 50 miles distant and only to be visited with team and camp outfit it will be seen that fresh specimens for the laboratory are hardly to be considered.

Because of the difficulties attending their study no literature has been produced especially devoted to this part of our flora. What is known is so widely scattered in all sorts of publications that access to such information is difficult and implies extensive library facilities. Difficult as it is to bring the plants to the laboratory it would be more difficult to take the library and laboratory to the plants. How these obstacles are to be met is for the future to solve but in the meantime this much is known, that many esculent species occur in the greatest abundance in our Coniferous forests.

Clavarias of the most delightful flavor are met with and are freely eaten by many who find them recommended by this fact solely, that browsing animals (deer) feed upon them unharmed. If one may take this as a safe test there are among the Agarics, the Boleti and the Lycoperdons many other species worthy of our acquaintance.

Besides the species enumerated in the following list of fungi, many more will undoubtedly be found when the lower altitudes of the state, as yet largely unexplored, shall have been carefully worked.

CLASS—PHYCOMYCETES.

PERONOSPORALES.

ALBUGINACEAE.

Albugo candida (Pers.) Kuntze,

On Thlaspi glaucum; Battle Lake, Carbon Co., Aug. 16, 1897 no. 4177.

CLASS—ASCOMYCETES.

EXOASCALES.

EXOASCACEAE.

Taphrina Quercus (Cke.) E. & E.

On Quercus macrocarpa; Sundance, Crook Co., July 3, 1896, no. 2167.

PERISPORIALES.

ERYSIBACEAE.

Podosphaera Allii Griffiths.

On Allium brevistylum; Williams and Griffiths, Big Horn Mts. near Buffalo, Johnson Co.

Podosphaera Oxyacanthae (DC.) De By.

David Griffiths: on Spiraea lucida, S. Fork Piney Creek, Sheridan Co.; on Prunus demissa, S. Fork Piney Creek; on Crataegus rivularis, Buttes.

Sphaerotheca Castagnei Lev.
Reported by David Griffiths from Sheridan, Johnson and Creek Counties, on eight different hosts.

Sphaerotheca Epilobii (Link.) De By.
On Epilobium adenocaulon; David Griffiths, Buffalo, Johnson Co.

Sphaerotheca Humuli (DC.) Burrill.
On Pedicularis sp.; Teton Mts., Uinta Co., Aug. 16, 1899, no. 6526: also by David Griffiths, on Viola Cadensis, Buffalo, Johnson Co.; on Geranium Richardsoni, Bear Lodge Mts., Crook Co.; on Humulus Lupulus, Buffalo.

Sphaerotheca mors-uvae (Schw.) B. &. C.
On Ribes lacustri; David Griffiths, Buffalo, Johnson Co.

Sphaerotheca pannosa (Wallr.) Fr.
On Rosa Woodsii; David Griffiths, Ft. McKinney, Johnson Co.

Phyllactinia suffulta (Reb.) Sacc.
On Amelanchier alnifolia: Sand Creek, Albany Co., Aug. 8, 1896, no. 2049; Laramie Hills, Albany Co., Sept. 13, 1899, no. 6908: on Betula occidentalis; David Griffiths, Ft. McKinney, Johnson Co.

Uncinula Salicis (DC.) Wint.
David Griffiths: on Salix sp., Buttes, Crook Co.; on Populus balsamifera, Buffalo, Johnson Co.

Microsphaera Alni (DC.) Wint.
On Lonicera glaucescens; David Griffiths, Bear Lodge Mts., Crook Co.

Microsphaera diffusa C. &. P.
David Griffiths: on Vicia Americana, Buffalo, Johnson Co.; on Glycyrrhiza lipidota, Buttes, Crook Co.

Microsphaera quercina (Schw) Burrill
On Quercus macrocarpa; David Griffiths, Buttes, Crook Co.

Microsphaera Ravenelii Berk
On Lathyrus venosus; David Griffiths, Bear Lodge Mts., Crook Co.

Microsphaera Vaccinii C. &. P.
On Vaccinium microphyllum; David Griffiths, Buffalo, Johnson Co.

Erysibe Cichoracearum DC.

Common: on Hydrophyllum occidentale, Cummins, Albany Co. July 29, 1895, no. 1516; on Grindelia sp., J. Johnson's ranch, Albany Co., Aug. 8, 1897, no. 3471a; on Prryocoma lanceolata, Laramie, Albany Co., Sept. 6, 1898, no. 5287; on Lapula sp., Teton Mts., Uinta Co., Aug. 16 1899, no. 6495. Also, collected by David Griffiths on twelve different hosts in Sheridan, Johnson and Crook counties.

Erysibe communis (Wallr.) Fr.

Very abundant and widely distributed: on Geranium incisum, Pass Creek, Sheridan Co., July 21, 1896, no. 2475; on Lydodesmia sp., Cabbria Canon, Converse Co., July 29, 1896, no. 2520; on Trifolium longipes, Evanston, Uinta Co., July 28, 1897, no. 3866a; on Lonicera involucrata, Evanston, July 27, no. 4124; on Anogra pallida, J. Johnson's ranch, Albany Co., Aug. 8, 1897, no. 4293; on Chrysothamnus Vaseyi, Laramie Hills, Albany Co., Sept. 28, 1897, no. 4301; on Polygonum aviculare, Laramie, Sept. 15, 1899, no. 6889. Also, by David Griffiths on seven other hosts in Johnson and Crook counties.

Erysibe Galeopsidis DC.

On Stachys palustris; David Griffiths, Ft. McKinney, Johnson Co.

Erysibe graminis DC.

On Poa nemoralis; Grand Encampment Creek, Carbon Co., Aug. 13, 1897, no. 3983a; David Griffiths, on three other hosts in Johnson Co.

PERISPORIACEAE.

Dimerosporium Collinsii (Schw.) E. & E.

On Amelanchier alnifolia; Sundance Mt., Crook Co., July 3, 1896, no. 2172.

Capnodium salicinum A. & S.

On the bark of living Populas tremuloides; Willow Creek, Albany Co., May 22, 1897, no. 2922.

Lasiobotrys Lonicerae Kze.

On Symphoricarpos sp.; Evanston, Uinta Co., July 27, 1897, no. 4112.

SPHAERIALES.

CUCURBITARIACEAE.

Otthia morbosa (Schw.) E. & E.

On Prunus Americana; Pass Creek, Sheridan Co., July 21, 1896, no. 2492: on Prunus demissa; Pass Creek, no. 2493.

SPHAERELLOIDEACEAE.

Sphaerella Fassiana De Not.

On Festuca Kingii; Sheep Mt., Albany Co., July 3, 1897, no. 3300a.

Sphaeria Coulteri Peck.

"Leaves and branchlets of pines;" near Yellowstone Lake, Aug. 1872—Coulter.

ASCOLICHENALES.*

CALICIACEAE.

Acolium tigillare (Ach.) De Not.

On dead dry wood; Telephone Canon, Albany Co., May 29, 1897, no. 2935.

CLADONIACEAE.

Stereocaulon tomentosum (Fr.) Th. Fr.

In small mats in pine woods: Lincoln Gulch, Albany Co., Aug. 13, 1896, no. 2620; Centennial Hills, Aug. 20, no. 2690.

Cladonia cariosa (Ach.) Spreng.

Sundance Mt., Crook Co., July 3, 1896, no. 2175.

Cladonia deformis (L.) Hoffm,

On moist rotten logs in the woods: Yellowstone Park; Glen Creek, July 1, 1899, no. 5616, Beaver Lake, July 24, no. 6123.

Clodonia degenerans Floerk.

Obsidian Creek, Yellowstone National Park, July 24, 1899, no. 6119.

Cladonia fimbriata coniocraea (Floerk) Wainio.

Centennial Hills, Albany Co., Aug. 20, 1896, no. 2710; Yancey's, Yellowstone National Park, July 17, 1899, no. 5932.

Cladonia fimbriata simplex (Weis.) Wainio.

Sundance Mt., Crook Co., July 3, 1896, nos. 2170, 2171; Lincoln Gulch, Albany Co., Aug. 12, 1896, nos. 2607, 2608; Battle Lake, Carbon Co., Aug. 15, 1897, no. 4167.

Cladonia gracilis (L) Nyl.

On moist ground; Centennial Hills, Albany Co., Aug. 20, 1896, no. 2711.

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*This list of Lichens, though not exhaustive, will give a fair notion of the prevailing forms. For their determination we are under many obligations to Prof. T. A. Williams of the Division of Agrostology of the U. S. Department of Agriculture .

Cladonia pyxidata (L.) Fr.

Centennial Hills, Albany Co., Aug. 18, 1895, no. 1749. Aug. 20, 1896, no. 2711.; Dome Lake, Sheridan Co., July 16, 1896, no. 2418; Sheep Mt., Albany Co., July 3, 1897, no. 3310; La Plata Mines, Aug. 28, 1898, no. 5229.

Cladonia sylvatica (L.) Hoffm.

Yellowstone National Park: Norris, July 25, 1898. no. 6149; Artist's Paint Pots, July 20, no. 6167.

Cladonia verticillata cervicornis (Ach.) Floerk. ?

Upper Geyser Basin, Yellowstone National Park, July 31, 1899, no. 6256.

LECIDIACEAE.

Lecidea atrobrunnea (D. C.) Schaer

Ferris Mt., Carbon Co., Nov. 16, 1897, nos. 4286, 4287. W. C. Knight; Dunraven Peak, Yellowstone National Park, Aug. 27, 1899. no. 6729.

Lecidea enteroleuca Fr.

Bitter Creek, Sweetwater Co., June 3, 1897, no. 3112.

Lecidea speira

Wamsutter, Sweetwater Co., June 4, 1897, no. 3131 a.

Umbilicaria polyphylla Hoffm.

Shoshone Lake, Yellowstone National Park, Sept., 1872—Coulter.

Umbillicaria rugifera Nyl.

Ferris Mts., Nov. 16, 1897, no. 4292, W. C. Knight.

Umbillicaria vellea (L.) Nyl.

Sundance Mt., Crook Co., July 3, 1896, no. 2174: Yellowstone National Park; Gibbon Meadow, July 28, 1899, no. 6193, Yellowstone Canon, Aug. 24, no. 6664.

PHYSCIACEAE.

Rinodina oreina (Ach.) Mass.

On rocks; Laramie Hills, Albany Co., Jan., 1896, no. 2832 in part; Ferris Mts., Carbon Co., July 24, 1898, no 4965.

Rinodina turfacea (Wahl.) Koerb.

Centennial Hills, Albany Co., Aug. 17, 1895, no. 1713.

Placodium cladodes Tuck.

Teton Mts., Uinta Co.—Coulter.

Placodium elegans (Link.) DC.

Dome Lake, Sheridan Co., July 18, 1896, no. 2451; Sheep Mt., Albany Co., July 3, 1897, no. 3347; Ferris Mts., Carbon Co., Nov. 16, 1897, no. 4291.

Placodium elegans trachyphyllum Tuck.

Laramie Hills, Albany Co., Jan., 1896, no. 2835; Evanston, Uinta Co., May 29, 1897, no. 2985.

Placodium fulgens trachyphyllum Tuck.

Laramie Hills, Albany Co., May 15, 1897, no. 2866.

Placodium vitellinum (Ehrh.)

On rocks; Laramie Hills, Albany Co., May 15, 1897, no. 2874.

Physcia hispida (Schreb.) Tuck

Sheep Mt., Albany Co., July 3, 1897, nos. 3349 b., 3348; Little Laramie River, July 4, 1897, no. 3343.

Physcia stellaris L.

On rocks: Willow Creek, Albany Co., May 22, 1897, no. 2927; Telephone Canon, May 29, 1897, no. 2934.

Theloschistes lychneus (Ach.) Tuck.

On dead twigs and bark of trees: Telephone Canon, Albany Co., Apr. 28, 1897, no. 2857, May 29, no. 2933; Centennial Valley, July 3, 1897, no. 3345; Evanston, Uinta Co., May 29, 1897, no. 3018.

Theloschistes polycarpus (Ehrh.) Tuck.

On dead twigs and bark of trees: Albany Co.: Laramie Hills, Jan., 1896, no. 2834; Willow Creek, May 22, 1897, no. 2928; Sheep Mt., July 3, no. 3349 a: Sweetwater Co.; Wamsutter, June 4, 1897, no. 3131 b.

PARMELIACEAE.

Urceolaria seraposa (L.) Nyl.

On gravelly soil; Willow Creek, Albany Co., May 22, 1897, no. 292.

Lecanora calcarea contorta Fr.

On loose stones; Medicine Bow, Carbon Co., June 5, 1897, no. 3144.

Lecanora chlorophana (Wahl.) Ach.

On rocks, very common: Sundance Mt., Crook Co., July 7, 1896, no. 2238; Laramie Hills, Albany Co., Jan., 1896, no. 2832 in part; Ferris Mts., Carbon Co., Nov. 16, 1897, no. 4288, W. C. Knight; Specimen Ridge, Yellowstone National Park, July 15, 1899, no. 5894.

Lecanora coarctata (Sm.) Ach.
"On rocks, Yellowstone Park"—Robert Reuleux.

Lecanora fuscata (Schrad.) Th. Fr.
On rocks; Ferris Mts., Carbon Co., Nov. 16, no. 4285 in part, W. C. Knight.

Lecanora Hageni Ach.
On dead stems of shrub; Wamsutter, Sweetwater Co., June 4, 1897, no. 3131 a.

Lecanora Haydeni Tuck.
Loose on the ground in Laramie Hills, Albany Co., May 10, 1898, no. 4306.

Lecanora hypoptoides Nyl.
"On dead wood, Yellowstone Park"—Robert Reuleux.

Lecanora muralis (Schreb.) Schaer.
On rocks; Ferris Mts., Carbon Co., Nov. 16, 1897, no. 4285 in part (W. C. Knight), July 24, 1898, no. 4964.

Lecanora polytropa illusoria Ach.
"On rocks, Yellowstone Park"—Robert Reuleux.

Lecanora rubina (Vill.) Ach.
On rocks: Willow Creek, Albany Co., May 22, 1897, no. 2926; J. Johnson's Ranch, Aug. 7, no. 3472.

Lecanora rubina opaca Ach.
On rocks: Bitter Creek, Sweetwater Co., June 3, 1897, no. 3111; Sheep Mt., Albany Co., July 3, 1897, no. 3111; Dunraven Peak, Yellowstone National Park, Aug. 27, 1899, no. 6728.

Lecanora Schleicheri (Ach.) Nyl.
On gravelly ground; Willow Creek, Albany Co., May 22, 1897, no. 2920.

Lecanora xanthophana dealbatu Tuck.
On rocks: Sweetwater Co.: Green River, May 30, 1897, no. 3057; Bitter Creek, June 3, no. 3110; Wamsutter, June 4, no. 3125: Specimen Ridge, Yellowstone National Park, July 15, 1899, no. 5893.

Parmelia conspersa (Ehrh.) Nyl.
Very common and widely distributed, on rocks: Pole Creek, Albany Co., July 1, 1895, no. 1387; Sundance Mt., Crook Co., July 7, 1896, no. 2237; Ferris Mts., Carbon Co., Nov. 16, 1898, no. 4290; (W. C. Knight), July 24, 1898, no. 4963; La Plata Mines Aug. 30, 1898, no.

5267; Gibbon Meadow, Yellowstone National Park, July 28, 1899, no. 6192.

Parmelia mollinscula Ach.
Loose on the ground, very common on the plains; Laramie, Albany Co., July 23, 1895, no. 1429; Red Desert, Sweetwater Co., June 3, 1897, no. 3124.

Parmelia olivacea aspidota Ach.
On twigs and stems: Albany Co.; Willow Creek, May 22, 1897, no. 2932, Sheep Mt., July 3, no. 3308, Centennial Valley, July 3, no. 3346.

Parmelia sarediata (Ach) Nyl.
On rocks; Willow Creek, Albany Co., May 22, 1897, no. 2929.

Parmelia saxatilis sulcata (Tayl.) Nyl.
Sundance Mt., Crook Co., July 3, 1896, no. 2161.

Parmelia tiliacea (Hoffm.) Floerk.
On rocks; Sundance Mt., Crook Co., July 3, 1896, no. 2179.

Cetraria Islandica Ach.
On moist ground under stunted spruce, at 10,000 ft, alt.; La Plata Mines, Albany Co., Aug. 29, 1898, no. 5249.

Cetraria Juniperina Pinastri Ach.
Sundance Mt., Crook Co., July 3, 1896, no. 2184.

Cetraria nivalis (L.) Ach.
La Plata Mines, Albany Co., Aug. 28, 1898, no. 5227.

Everina vulpina (L.) Ach.
Centennial Valley, Albany Co., Aug. 17, 1895, no. 1699: Yellowstone Park; Undine Falls, July 6, 1899, no. 5689, Dunraven Peak, Aug. 27, no. 6701.

Alectoria jubata Fr.
Shoshone Lake, Yellowstone National Park, Sept., 1872—Coulter.

Usnea barbata hirta Fr.
Sundance Mt., Crook Co., July 3, 1896, no. 2162.

VERRUCARIACEAE.

Endocarpum miniatum (L.) Schaer
Laramie Hills, Albany Co., May 15, 1897, no. 2870.

PANNARIACEAE.

Pannaria brunnea (Sw.) Mass.
On wet ground; Centennial Hills, Albany Co., Aug. 20, 1896, no. 2698.

Pannaria Hypnarum (Hoffm.)

On wet ground; La Plata Mines, Albany Co., Aug. 25, 1898, no. 5179.

Peltigera aphthosa (L.) Hoffm.

On moist ground in woods, very common: Albany Co.: Centennial Valley, Aug. 18, 1895, no. 1749, Laramie Peak, Aug. 8, 1895, no. 1644, Centennial Hills, Aug. 20, 1896 no. 2709: Tower Falls, Yellowstone National Park, July 16, 1899, no. 5907.

Peltigera canina (L.) Hoffm.

On moist ground: Cummins, Albany Co., July 29, 1895, no. 1508; Dome Lake, Sheridan Co., July 16, 1896, no. 2419.

Peltigera rufescens (Neck.) Hoffm.

Druid Peak, Yellowstone National Park, July 12, 1899, no. 5798.

HYSTERIALES.

HYSTERIACEAE.

Hysterium Pinastri Fr.

"On pine leaves;" "near Yellowstone Lake, August 23." 1872—Coulter.

PHACIDIALES.

PHACIDIACEAE.

Rhytisma salicinum (Pers.) Fr.

On Salix sp.; Sand Creek, Carbon Co., July 26, 1898, no. 4953. On Salix arctica petraea; La Plata Mines, Albany Co., Aug. 28, 1898, no. 5219.

PIZIZALES.

MOLLISIACEAE.

Pseudopeziza Medicaginis (Lib.) Sacc.

On Medicago sativa; Laramie Experiment Farm, Albany Co., Sept. 14, 1898, no. 5344.

CENANGIACEAE.

Cenangella deformata Pk.

On the bark of Juniperus scopulorum; Laramie Hills, Albany Co., March 6, 1898, no. 4300.

HELVELLALES.

HELVELLACEAE.

Morchella conica Pers.

In moist ground; Laramie Albany Co., May 31, 1897, no. 2944.

CLASS—FUNGI IMPERFECTI.

SPHAEROPSIDALES.

SPHAEROPSIDACEAE.

Phyllosticta ferax E. & E.

On Lupinus humicola; Willow Creek, Albany Co., July 1, 1898, no. 4380.

Ampelomyces quisqualis Ces.

Reported by David Griffiths from northeastern Wyoming; parasitic on species in several genera of Erysibaceae and on Oidium spp. of the Moniliaceae.

Septoria Urticae Desm.

On Urtica sp.; Little Laramie River, Albany Co., July 4, 1897, no. 3342.

LEPTOSTROMATACEAE.

Piggotia Negundinis E. & E.

On Acer Negundo; Sundance Creek, Crook Co., July 6, 1896, no. 2827.

MONILIALES.

MONILIACEAE.

Ramularia Sidalceae E. & E.

On Sidalcea candida; Cummins, Albany Co., July 29, 1895, no. 1468: collected but once before, viz; in British Columbia, by Dr. Macoun.

DEMATIACEAE.

Hadrotrichum Lupini E. & E.

On Lupinus humicola; Willow Creek, Albany Co., July 1, 1898, no. 4380 a.

Cladosporium myriosporum E. & D.

On the pods of Pisum sativuns, grown on the Laramie Experiment Farm, Albany Co., Aug. 20, 1896.

CLASS—BASIDIOMYCETES.

USTILAGINALES.

USTILAGINACEAE.

Ustilago bromivora Fisch.

On Bromus spp.: Battle Lake, Carbon Co., Aug. 16, 1897, no. 4179; Nez Perces Creek, Yellowstone National Park, July 29, 1899, no. 6218; Yellowstone Lake, Aug. 23, no. 6621.

Ustilago Caricis DC.

On Carex spp.: Lincoln Gulch, Albany Co., Aug. 12, 1896, no. 2604; Centennial Hills, Albany Co., Aug. 20, 1896, no. 2687; Battle Lake, Carbon Co., Aug. 16, 1897, no. 4178; Snake River, Yellowstone National Park, Aug. 12, 1899, no. 6432.

URIDINALES.

MELAMPSORACEAE.

Chrysomyxa Ledi (A. & S.)

On Dedum glandulosum; Sylvan Geysers, Yellowstone National Park, July 26, 1899, no. 6176.

Chrysomyxa Pyrolae (DC.) Rostr.

On Pyrola secunda; La Plata Mines, Albany Co., Aug. 24, 1898, no. 5107.

Cronartium asclepiadeum Thesii Berk.

On Comandra pallida; Medicine Bow River, Carbon Co., Aug. 20, 1897, no. 4257.

Melampsora farinosa (Pers.) Schroet.

Very common on Salix spp.: Cummins, Albany Co., July 29, 1895, no. 1520; Centennial Valley, Aug. 25, 1895, no. 1864.

Melampsorella Cerastii (Pers.) Schrtr.

On Cerastium arvense; Green Top, Albany Co., June 29, 1897, no. 3230: on Alsine Baicalensis; La Plata Mines, Albany Co., Aug. 24, 1898, no. 5102.

Peridermium elatinum A. & S.

On Picea Engelmanni; Battle Lake, Carbon Co., Aug. 18, 1897, no. 4244.

PUCCINIACEAE.

Uromyces bicolor E. & E.

On Allium sp.; Yancey's, Yellowstone National Park, July 17, 1899, no. 5920.

Uromyces Eriogoni Ell & Hark.

On Eriogonum unbellatum; Ferris Mts., Carbon Co., July 23, 1898, no. 4952: on Eriogonum brevicaule; Wallace Creek, Natrona Co., July 30, 1898, no. 5003.

Uromyces Erythronii DC.

On Erythronium grandiflorum; Obsidian Creek, Yellowstone National Park, July 24, 1899, no 6114.

Uromyces Glycyrrhizae Magnus
Fremont and often abundant on Glycyrrhiza lepidota: Pass Creek, Sheridan Co., July 21, 1896, no. 2474; Granger, Sweetwater Co., July 30, 1897, no. 4136; Gardiner River, Yellowstone National Park, July 19, 1899, no. 5971.

Uromyces Fabae (Pers.) De By.
On Vicia sp.; Bitter Creek, Sweetwater Co., July 1897, no. 3527.

Uromyces Junci (Schw.) Tul.
On Junci (Schw.) Laramie, Albany Co., Dec., 1895, no. 1207.

Uromyces oblongisporus E. & E.
On Artemisia tridentata; South Butte, Sweetwater Co., July 13, 1897, no. 3546.

Uromyces Pisi (Pers·) De By.
On Vicia sp.; Evanston, Uinta Co., July 27, 1897, no. 4106.

Uromyces Polygoni (Pers.) Fckl.
On Rumex pauciflorus; Snake River, Yellowstone National Park, Aug. 13, 1899, no. 6438.

Uromyces Rudbeckiae Arthur & Holway.
On Rudbeckia laciniata; Pass Creek, Sheridan Co., July 21, 1896, no. 2476.

Uromyces Solidagonis Sommerf.
On Solidago Canadensis (?); Sundance, Crook Co., July 4, 1896, no. 2192.

Uromyces Sophorae Pk.
On Sophora sericea; Mill Creek, Converse Co., Aug. 12, 1898, no. 5051.

Uromyces Zygadeni Pk.
On Zygadenus venenosus; Willow Creek, Albany Co., May 22, 1897, no. 2924.

Puccinia Adoxae (Hedeo).
On Adoxa Moschatellina; Yancey's, Yellowstone National Park, July 17, 1899, no. 5929.

Puccinia aunulata E. & E.
On Chamaenerion angustifolium; Yancey's Yellowstone National Park, July 17, 1899, no. 5930.

Puccinia Asteris Duby
On Aster conspicuus; Wolf Creek, Canon, Sheridan Co., July 12,

1896, no. 2293: on Aster sp.; Madison Canon, Yellowstone National Park, Aug. 30, 1899, no. 6780.

Puccinia Balsamorrhizae Pk.

On Balsamorrhiza sagittata; Indian Grove Mts., Carbon Co., July 17, 1898, no. 4900.

Puccinia cladophila Pk.

On Ptiloria pauciflora: Garfield Peak, Natrona Co., July 29, 1894, no. 2830; July 31, 1898, no. 5012.

Puccinia conferta Dietel.

On Artemisia tridentata; Sheep Mt., Albany Co., July 3, 1897, no. 3309 a; Seminole Mts., Carbon Co., July 22, 1898, no. 4945; Laramie Hills, Sept. 13, 1899, no. 6906. on Artemisia cana; Poison Spider Creek, Aug. 1, 1898, no. 5021.

Puccinia consimilis E. & E.

On Schoenocrambe linifolia: Granger, Sweetwater Co., June 10, 1898, no. 4621; Cokeville, Uinta Co., June 11, 1898, no. 4661.

Puccinia Caricis (Schum.) Reb.

On Carex filifolia; Pine Bluffs, Laramie Co., May 15, 1897, no. 2896.

Puccinia cornigera E. & E.

On Tetraneuris Torreyana; Freezeout Hills, Carbon Co., July 10, 1898, no. 4852.

Puccinia Epilobii DC.

On Epilobuim paniculatum: Yellowstone National Park: Nez Perces Creek, July 29, 1899, no. 6223; Snake River, Aug. 12, no. 6431.

Puccinia Erigerontis E. & E

On Erigeron caespitosus; Crow Creek, Laramie Co., July 9, 1896, no. 2847; Ferris Mts., Carbon Co., July 23, 1898, no. 4954: on Erigeron microlonchus; Willow Creek, Albany Co., July 1, 1898, no. 4379: on Erigeron Eatoni; Freezeout Hills, Carbon Co., July 10, 1898, no. 4490.

Puccinia Gayophyti Pk.

On Gayophytum ramosissimum: J. M. Bates, Cambria, Converse Co., June 18, 1896, no. 443; Centennial Valley, July 3, 1897, no. 3285: Seminole Mts., Carbon Co., July 22, 1898, no. 4935.

Puccinia gibberulosa Schitr ?

On Cyrtorhyncha ranunculina; Laramie Hills, Albany Co., June 6, 1896, no. 1906.

Puccinia graminis Pers.

On Poa laevigata; Wamsutter, Sweetwater Co., July 10, 1897, no. 3668 a: on Festuca Kingii; Wallace Creek, Natrona Co., July 30, 1898, no 5004.

Puccinia Harknessii Vize.

On Ptiloria sp.; Fort Steele, Carbon Co., June 18, 1898, no. 4827.

Puccinia Helianthi Schw.

On Helianthus sp.; Cambria Canon, Converse Co., July 29, 1896, no. 2542.

Puccinia Heucherae Sz.

On Heuchera parviflora; Laramie Hills, Albany Co., June 16, 1897, no. 3155.

Puccinia Hieracii (Schum.) Mart.

On Crepis intermedia (?); Seminole Mts., Carbon Co., July 22 1898 no. 4940.

Puccinia intermixta Pk.

Rare; on Iva axillaris: Bitter Creek, Sweetwater Co., July 12, 1897, no. 3526; Casper, Natrona Co., Aug. 2, 1898, no. 5022.

Puccinia Lygodesmiae Pk.

On Gymnolomia miltiflora; Centennial Hills, Albany Co., Aug. 20, 1896, no. 2715.

Puccinia Menthae Pers.

On Mentha Canadensis; Laramie River, Albany Co., Sept. 25, 1897, no. 4302.

Puccinia mirabillissima Pk.

On Berberis nana: Laramie Hills, Albany Co., May 21, 1898, no. 4309; Mommoth Hot Springs, Yellowstone National Park, July 1, 1899, no. 5625.

Puccinia Musenii E. & E.

On Musenium tenuifolium; Freezeout Hills, Carbon Co., July 10, 1899, no. 4491.

Puccinia Phragmitis Schum.

On Spartina gracilis; Laramie River, Albany Co., Aug. 31, 1897, no. 4268.

Puccinia rubigo-vera (DC.) E. & E.

On Elymus sp.; Iron Mt., Laramie Co., Aug. 26, 1896, no. 2732.

Puccinia Saxifragae Schlect.

On Saxifraga cernua; La Plata Mines, Albany Co., Aug. 24, 1898, no. 5124.

Puccinia Tanaceti DC.

On Artemisia cana; W. C. Knight, Steamboat Lake, Albany Co., Oct. 28, 1896, no. 2825: on Artemisia tridentata; Laramie Hills, Sept. 14, 1898, no. 4343.

Puccinia Thalictri Chev.

On Thalictrum sp.; Sundance Creek, Crook Co., July 2, 1896, no. 2105: on Thalictrum sp.; Lewis River, Yellowstone National Park, Aug. 9, 1899, no. 6389.

Puccinia variabilis Grev.

On Taraxacum sp.; Centennial Valley, Albany Co., Aug. 17, 1896, no. 2660.

Puccinia Violae (Schum.) DC.

On Viola sp.; Pass Creek, Sheridan Co., July 21, 1896, no. 2489: Battle Lake, Carbon Co., Aug. 16, 1897, no. 4192.

Gymnosporangium clavipes C. & P.

On Juniperus scopulorum; Laramie Hills, Albany Co., May 10, 1896, no. 1886.

Phragmidium fragariastri DC.

On Potentilla sp.; Freezeout Hills, Carbon Co., July 10, 1898, no. 4851.

Phragmidium subcortium Schrank.

Frequent on species of Rosa: Cummins, Albany Co., July 29, 1895, no. 1499; Sundance, Crook Co., July 2, 1896, no. 2100; Sundance Mt., July 3, no. 2163; Yancey's, Yellowstone National Park, July 17, 1899, no. 5946.

Aecidium abundans Pk.

Very common on Symphoricarpos oreophilus; Cummins, Albany Co., July 29, 1895, no. 1498.

Aecidium Allenii Clinton.

On Lepargyraea Canadensis: Yellowstone National Park; Specimen Ridge, July 15, 1899, no. 5884, Snake River, Aug. 12, no. 6430.

Aecidium Aquilegiae Pers.

On Aquilegia caerulea (?): Laramie Peak, Albany Co., Aug. 7, 1895, no. 2831; North Vermillion Creek, Sweetwater Co., July 17, 1897, no. 3558; Lewis River, Yellowstone National Park, Aug. 9, 1899, no. 6390.

Aecidium Asterum Schw.

On aster sp (?); Sundance Mt., Crook Co., July 3, 1896, no. 2176.

Aecidium Clematidis DC.

On Clematis ligusticifolia: Wolf Creek, Sheridan Co., July 12, 1896, no. 2310; Hat Six Falls, Natrona Co., Aug. 7, 1898, no. 5033.

Aecidium Compositarum Mart.

On Helianethus sp.; Centennial Valley, Albany Co., July 3, 1897, no. 3289: on Aster sp (?); North Vermillion Creek, Sweetwater Co., July 17, 1897, no. 3572: on Aster sp.; Yancey's, Yellowstone National Park, July 17, 1899, no. 5921: on Agoseris sp.; Snake River, Aug. 13, no. 6453.

Aecidium Euphorbiae Pers.

On Euphorbia sp.; Uva, Laramie Co., Aug. 26, 1896, no. 2744: on Euphorbia montana; Ferris Mts., Carbon Co., July 24, 1898, no. 4958.

Aecidium Eurotiae E. & E.

On Eurotia lanata; Laramie, Albany Co., June 15, 1897, no. 3149.

Aecidium Glaucis Dozy & Molkenb.

On Glaux maritima; Laramie, Albany Co., June 15, 1897, no. 3150.

Aecidium Grossulariae (Schum.) E. & E.

On Ribes sp.: Moorcroft, Crook Co., July 8, 1896, no. 2244.

Aecidium Hpdrophylli Pk.

On Hydrophyllum occidentale; Green Top, Albany Co., June 29, 1897, no. 3231: on Hydrophyllum capitatum; Mammoth Hot Springs, Yellowstone National Park, June 30, 1899, no. 5599.

Aecidium Lysimachiae Schlect.

On Steironema ciliata; Ranchester, Sheridan Co., July 13, 1896, no. 2286.

Aecidium monoicum Pk.

Frequent on Schoenocrambe linifolia; Laramie Hills, Albany Co., May 23, 1894, no. 50.

Aecidium Oenotherae Mont,

On Pachylophus caespitosus; Pole Creek, Laramie Co., no. 133: on Pachylophus montanus; Laramie, Albany Co., May 31, 1899, no. 6831; on Taraxia heterantha; Golden Gate Yellowstone National Park, June 28, 1899, no. 5534.

Aecidium Orobi Pers.

On Lathyrus ochrolucus; Sundance Creek, Crook Co., July 2, 1896, no. 2110.

Aecidium Peckii De Toni.

On Anogra biennis; Madison Canon, Yellowstone National Park, Aug. 29, 1899, no. 6756.

Aecidium Phlogis E. & E.

On Phlox Hoodii glabrata; Pine Ridge, Albany Co., June 7, 1898. no. 4341.

Aecidium Plantaginis Ces.

On Plantago eriopoda; Laramie, Albany Co., June 9, 1897, no. 2947.

Aecidium porosum E. & E.

On Vicia sp.; Bitter Creek, Sweetwater Co., June 17, 1898. no. 4785.

Aecidium pyratum Sch.

"Headwater of Snake River," Yellowstone National Park, Sept. 11, 1872—Coulter.

Aecidium Ranunculacearum DC.

On Oxygraphis Cymbalaria; Laramie, Albany Co., June 18, 1896. no. 1972.

Aecidium Sarcobati Pk.

On Sarcobatus vermiculatus; Little Laramie River, Albany Co., June 25, 1897, no. 3210.

Aecidium Sommerfeldtii Johans.

On Thalictrum sp.: Sheridan, Sheridan Co., July 10, 1896, no. 2270; Head of Pole Creek, Albany Co., June 19, 1897, no. 3193.

Aecidium tuberculatum E. & K.

Very abundant on Sidalcea malvaeflora on Miller's Ranch in the Seminole Mts., Carbon Co., July 23, 1898, no. 4946.

Roestelia aurantiaca Pk.?

On Amelanchier alnifolia; Indian Grove Mts., Carbon Co., July 17, 1898, no. 4887.

Uredo Polypodii (Pers.) DC.

On Cystoperis fragilis; La Plata Mines, Albany Co., Aug. 27. 1898, no. 5196.

Uredo ribicola E. & E.

On Ribes sp.; Laramie, Albany Co., Sept. 8, 1898, no. 5305.

EXOBASIDIALES.

EXOBASIDIACEAE.

Exobasidium Vaccinii (Fckl.) Wor.

On Vaccinium caespitosum; Little Goose Creek Hills, Sheridan Co., July 16, 1896, no. 2367; on Vaccinium membranaceum, Teton Mts., Uinta Co., Aug. 16, 1899.

AGARICALES.

THELEPHORACEAE.

Thelephora terrestris Fr.

"Along the Yellowstone," 1872—Coulter.

CLAVARIACEAE.

Clavaria formosa Pers.

Jackson's Lake, Uinta Co., Sept., 1872.—Coulter.

Clavaria sp.

Battle Lake, Aug. 15, 1897, no. 4199.

This genus is abundant, represented in the coniferous woods by at least one excellent edible species.

HYDNACEAE.

Hydnum imbricatum L.

In moist woods; Battle Lake, Carbon Co., Aug. 16, 1897, no. 4197.

POLYPORACEAE.

Merulius lachrymaus (Jacq.) Fr.

In damp cellar; Cheyenne, Laramie Co., Sept. 15, 1895, no. 1873.

Trametes sp.

Little Goose Creek Hills, Sheridan Co., July 16, 1896, no. 2368.

Polyphorus cuniabarinus (Jacq.) Fr.

Medicine Bow Mts., Albany Co., Aug. 12, 1896, no. 2841.

Polyporus leucospongia Cooke.

Sundance Mt., Crook Co., July 7, 1896, no. 2236.

Polyporus officinalis (Vill.) Fr.

Growing on the under side of moist logs of Pseudotsuga Douglasii; B. C. Buffum, Telephone Canon, Albany Co., 1892, no. 2841; also, secured in the same locality in 1897 by Aven Nelson.

BOLETACEAE.

Boletus spp.

Battle Lake, Aug. 16, 1897, no. 4199.

This genus is abundantly represented in forests mountain areas. Many no doubt edible.

AGARICACEAE.

Agaricus campester L.

In waste grounds and well manured lots. Common and abundant. Frequently collected for food.

Agaricus silvaticus Schaeff.

Less common than the preceding. In open woods, especially where cattle have wintered.

An excellent edible species. Bacon Ranch, June, 1897.

Coprinus atramentarius (Bull.) Fr.

Moist ground along an irrigating ditch; Laramie, Albany Co., Sept. 7, 1897, no. 4280.

LYCOPERDALES.

LYCOPERDACEAE.

Tylostoma fimbriatum Fr.

On river bottoms; Laramie, Albany Co., Sept., 1896, no. 2826.

Lycoperdon gemmatum Batsch.

On rotten logs; Pole Creek, Albany Co., May 30, 1896, no. 2199.

Lycoperdon pyriforme Schaeff.

Battle Lake, Carbon Co., Aug. 17, 1897, no. 4238 (?); "near Yellowstone Lake, Aug. 23," 1872.—Coulter.

NOTE.—THE FERNS and FERN-ALLIES have not been included in this list, since there are in the state only a relatively small number and these were published with notes upon them, by Mr. Elias Nelson, in the January number (1899) of the Fern Bulletin. Those desiring to know what species occur here are referred to that publication.

METEOROLOGICAL REPORT

. . . FOR THE YEAR . . .

Beginning January 1 and Ending December 31, 1899.

BY C. B. RIDGAWAY.

Meteorological Report for 1899.

The work of the meteorological department has been a continuation of that of previous years. Observations upon atmospheric conditions and soil temperature at various depths have been taken twice daily, at 7 a. m. and 7 p. m.

The observations have been reported monthly to the United States Weather Bureau at Washington, and to the Wyoming Section at Cheyenne. Weekly climate and crop reports have also been sent to the Cheyenne office.

The latitude of the Station is 41° 18′ 37.09″ North, and the longitude 105° 34′ 53.75″ West from Greenwich. The altitude of the standard barometer is 7,191 feet.

The equipment of the Station for meteorological observations consists of the following: A quadruple register, with two automatic pens for registering the velocity and direction of the wind; a Draper's self-recording thermometer; a standard mercurial barometer; one Richard's self-registering aneroid barometer; a sling psychrometer; six soil thermometers at different depths in the ground; a maximum and a minimum self-registering thermometer; a hook-gauge and evaporation tank; a standard eight inch rain gauge; a maximum and a minimum self-registering solar radiation thermometer.

Summary.

Highest temperature, 87, June 29, July 25.

Lowest temperature, —40, February 12.

Mean temperature for year, 38.8.

Greatest daily range of temperature, 63, February 12.

Lowest daily range, 5, October 9.

Mean daily range of temperature for year, 24.4.

Mean relative humidity for the year, 57.1.

Lowest relative humidity, 6, September 7.

Highest dew point, 60, September 5.

Lowest dew point, —38, February 6.

Mean dew point for the year, 23.9.

Highest barometer, 23.502, September 25.

Lowest barometer, 22.442, January 31.

Mean barometer for the year, 23.079.

Highest monthly precipitation, 2.01 inches, in July.

Lowest monthly precipitation, .07, in November.

Greatest amount of precipitation during any single storm, .91 in., July 13.

Total precipitation: 1891, 13.92 in.; 1892, 12.73 in.; 1893, 3.84 in.; 1894, 7.63 in.; 1895, 11.15 in.; 1896, 10.75 in.; 1897, 11.91 in.; 1898, 7.63 in.; 1899, 11.84 in.

Mean precipitation for nine years, 10.15 in.

Evaporation, 20.58 inches, from April 22 to October 15.

Greatest monthly evaporation, 4.42, in May.

Mean soil temperatures: 3 in., 43.2; 6 in., 42.7; 12 in., 44.1; 24 in., 43.7; 36 in., 44.1; 72 in., 43.2.

Prevailing direction of the wind, southwest.

Number of clear days during year, 178.

Number of partly cloudy days during year, 142.

Number of cloudy days during year, 45.

Number of days on which .01 or more precipitation fell, 75.

Greatest velocity of wind, 58 miles per hour, May 21.

Total number of miles traveled by wind during the year, 117,284.

Greatest number of miles traveled in one month, 12,787, January.

Least number of miles traveled in one month, 7,245, November.

Average number of miles for each month, 9,773.6.

Greatest number of miles in one day, 744, May 21.

Least number of miles in a day, 97, December 13.

Mean daily distance traveled, 321.3.

Mean hourly distance traveled, 13.3:

TABLE I.*—*Temperature, 1899.*

	JANUARY						FEBRUARY						MARCH					
Date	7 a.m.	7 p.m.	Max.	Min.	Mean	Range	7 a.m.	7 p.m.	Max.	Min.	Mean	Range	7 a.m.	7 p.m.	Max.	Min.	Mean	Range
1	17	27	33	5	19	28	3	7	13	2	7.5	11	27	28	34	27	30.5	**7**
2	29	26	43	15	29	28	13	9	20	5	12.5	15	26	24	37	24	30.5	13
3	23	12	30	13	21.5	17	6	3	16	1	8.5	15	15	9	32	10	21	22
4	10	12	**16**	3	9.5	13	—4	9	6	—13	—3.5	19	14	14	21	7	14	14
5	10	9	**16**	4	10	**12**	—13	—15	—1	—13	—7	12	4	20	24	0	12	24
6	9	15	20	—2	9	22	—**35**	—**16**	—9	—39	—24	30	25	32	26	17	21.5	9
7	18	21	31	12	21.5	19	13	9	9	—22	—6.5	31	33	36	40	23	31.5	17
8	13	17	32	6	19	26	14	18	24	4	14	20	44	36	51	31	41	20
9	14	29	38	9	23.5	29	10	23	25	11	18	14	37	**39**	**52**	29	40.5	23
10	11	30	**46**	12	29	**34**	26	—12	28	11	19.5	17	20	11	47	20	33.5	27
11	23	24	38	17	27.5	21	—12	—4	—**14**	—36	—**2.5**	12	11	16	20	9	14.5	11
12	16	21	38	16	27	22	—8	22	23	—**40**	8.5	**63**	16	24	25	12	18.5	13
13	10	13	24	7	15.5	17	20	15	21	13	17	**8**	17	28	30	12	21	18
14	18	21	32	10	21	22	11	16	28	1	14.5	27	16	14	37	15	26	22
15	19.	26	33	15	24	18	24	25	35	11	23	24	15	31	22	0	11	22
16	**30**	28	36	24	30	**12**	18	17	26	10	18	16	34	36	42	26	35	14
17	21	12	30	14	22	16	10	25	29	5	17	24	23	9	47	20	33.5	27
18	23	26	38	8	23	30	12	25	33	9	21	24	3	28	33	—3	15	36
19	25	22	38	24	**31**	14	**29**	**34**	**43**	**24**	**33.5**	19	28	31	32	24	28	8
20	23	26	38	21	29.5	17	25	19	29	19	24	10	31	32	43	27	35	16
21	29	**36**	43	**25**	34	18	14	15	22	10	16	12	27	21	39	26	32.5	13
22	21	12	21	7	14	14	3	—10	—3	—28	—15.5	25	19	26	25	15	20	10
23	—**1**	13	25	—**3**	11	28	19	24	34	—13	10.5	47	33	**39**	34	26	30	8
24	19	11	25	10	17.5	15	22	20	36	16	26	20	**38**	**39**	45	**35**	40	10
25	22	30	34	6	20	28	0	1	20	—10	5	30	34	20	50	33	**41.5**	17
26	20	28	32	17	24.5	15	—1	14	20	—7	6.5	27	2	**2**	35	2	18.5	33
27	17	25	28	16	22	12	22	21	34	3	18.5	31	—**10**	3	**3**	—**14**	—**5.5**	17
28	11	**0**	15	—2	**6.5**	17	20	32	35	14	24.5	21	16	27	15	—4	—**5.5**	19
29	23	26	29	—2	13.5	31							29	28	32	24	28	8
30	22	20	25	19	22	6							17	8	27	16	21.5	11
31	20	26	31	—**3**	14	**34**							—5	23	28	—9	9.5	**37**
Sum..	564	654	958	323	640	635	281	346	582	—52	265	624	639	734	1038	482	760	556
Mean	18.2	21.1	30.9	10.4	20.6	20.5	9.3	12.3	20.8	—1.8	9.5	22.3	20.6	23.7	33.5	15.5	24.5	18

*In all the tables figures printed in bold-faced type give the highest or lowest readings for each month.

TABLE I (Continued).—*Temperature, 1899.*

	APRIL						MAY						JUNE					
Date	7 a.m.	7 p.m.	Max.	Min.	Mean	Range	7 a.m.	7p.m.	Max.	Min.	Mean	Range	7 a.m.	7 p.m.	Max.	Min.	Mean	Range
1	24	32	**28**	18	23	10	42	35	45	30	37.5	15	52	57	64	39	51.5	25
2	30	28	40	24	32	16	29	**27**	54	27	40.5	27	44	**42**	55	39	47	16
3	24	30	40	21	30.5	19	**25**	30	**35**	**18**	**26**.5	17	43	48	51	40	45.5	**11**
4	36	38	38	27	32.5	11	34	39	36	26	31	**10**	44	46	51	40	45.5	**11**
5	25	**24**	46	24	35	22	36	46	51	26	38.5	25	52	55	66	40	53	26
6	**22**	35	31	**12**	**21.5**	19	35	41	56	26	41	30	40	44	**49**	36	**42.5**	13
7	26	31	42	24	33	18	37	40	59	34	46.5	25	46	51	64	30	47	34
8	29	41	39	20	29.5	19	34	49	49	26	37.5	23	49	49	59	38	48.5	21
9	43	45	50	31	40.5	19	48	46	61	36	48.5	25	46	57	64	37	50.5	27
10	46	46	61	36	48.5	25	42	53	53	29	41	24	55	64	65	30	52	26
11	44	48	57	38	47.5	19	52	58	60	40	50	20	59	67	73	51	62	22
12	46	46	56	36	46	20	41	46	69	40	54.5	29	47	53	60	44	52	16
13	41	41	63	38	50.5	25	49	60	56	35	45.6	21	**36**	47	53	35	44	18
14	38	43	51	28	39.5	23	45	55	**72**	45	**58**.5	27	40	56	60	**29**	44.5	31
15	31	45	55	21	38	34	55	54	71	**46**	**58**.5	25	49	58	64	36	50	28
16	**48**	50	53	35	44	18	40	41	58	30	44	28	54	65	72	40	56	32
17	27	36	64	23	43:5	41	41	53	56	28	42	28	60	73	81	46	63.5	35
18	41	45	44	24	34	20	48	57	60	29	44.5	31	58	72	80	49	64.5	31
19	28	26	61	24	42.5	**37**	52	43	67	37	52	30	**67**	65	70	49	59.5	21
20	27	34	39	23	31	16	37	38	65	38	51.5	27	66	61	78	**53**	65.5	25
21	31	49	41	22	31.5	19	35	39	44	28	36	16	52	64	78	44	61	34
22	44	52	59	28	43.5	31	39	45	50	30	40	20	51	50	63	33	48	30
23	45	**57**	**65**	30	47.5	35	47	57	56	32	44	24	58	57	75	45	60	30
24	46	49	64	**39**	**51.5**	25	50	59	59	33	46	26	57	56	76	37	56.5	39
25	45	55	59	31	45	28	**56**	**61**	62	44	53	18	59	69	80	43	61.5	37
26	41	41	63	33	48	30	46	53	69	35	52	34	53	63	70	49	59.5	21
27	37	36	53	25	39	28	44	44	64	33	48.5	31	60	67	79	44	61.5	35
28	29	27	50	23	36.5	27	44	50	61	33	47	28	59	67	82	49	65.5	33
29	28	28	32	25	28.5	**7**	51	60	57	31	44	26	65	**75**	**87**	47	67	**40**
30	32	37	42	29	35.5	13	46	48	66	32	49	**34**	66	73	86	40	**67.5**	37
31							45	55	54	28	41	26						
Sum	1054	1193	1486	812	1140	674	1325	1482	1775	1045	1410	730	1587	1771	2055	1250	1652.5	805
Mean	35.1	39.8	49.5	27.0	38.3	22.4	42.7	47.8	57.3	33.7	45.5	23.5	52.9	59	68.5	41.6	55.8	26.8

TABLE I (Continued).—*Temperature*, 1899.

	JULY						AUGUST						SEPTEMBER					
Date	7 a.m.	7 p.m.	Max.	Min.	Mean	Range	7 a m.	7 p.m.	Max.	Min.	Mean	Range	7 a.m	7 p.m.	Max.	Min.	Mean	Range
1	59	55	72	**40**	56	32	62	56	80	43	61	35	58	**67**	82	49	**65**	33
2	58	54	72	47	59.5	25	57	66	78	53	65	25	64	60	78	50	64	28
3	55	52	71	49	60	22	56	55	66	**54**	60	12	58	59	83	44	64	38
4	60	64	79	44	61.5	35	56	54	**63**	53	58	**10**	51	65	82	40	61	42
5	61	65	81	46	63.5	35	59	58	74	47	60	27	58	**67**	**85**	**56**	70	29
6	62	56	78	47	62.5	31	58	57	74	44	61	32	**66**	65	79	42	60	37
7	57	62	73	45	59	28	59	61	71	49	60	22	54	54	67	45	56	22
8	63	67	84	50	67	34	56	64	75	49	62	26	47	50	59	41	50	18
9	64	66	80	45	62.5	35	56	59	75	45	59	32	45	50	71	35	63	36
10	62	65	85	49	67	36	55	65	76	42	59	34	41	50	77	**29**	53	48
11	58	61	78	48	63	30	59	67	77	43	60	34	52	64	80	44	62	36
12	64	63	73	51	62	22	58	62	72	46	59	26	49	61	81	39	60	42
13	63	57	72	47	59.5	25	51	60	75	44	59	31	51	48	76	41	58	35
14	54	56	71	49	60	22	60	69	80	47	64	33	48	53	71	41	56	30
15	53	**51**	69	42	55.5	27	62	65	**83**	51	67	32	44	**45**	57	43	50	**14**
16	54	59	**64**	46	**55**	**18**	61	**53**	76	**54**	65	22	41	46	**55**	39	**47**	16
17	55	62	74	45	59.5	29	55	63	74	46	60	28	44	54	65	35	50	30
18	57	63	72	49	60.5	23	54	61	77	41	59	36	40	54	66	33	50	33
19	59	**71**	79	49	64	30	55	60	68	50	59	18	38	51	64	31	**47**	33
20	**68**	70	81	45	63	**36**	51	66	76	**39**	58	37	42	57	69	32	50	37
21	64	68	85	49	67	**36**	64	68	81	47	64	34	48	57	74	35	54	39
22	65	67	86	**52**	**69**	34	**47**	64	75	42	58	33	39	56	73	31	52	42
23	60	69	76	50	63	26	48	57	68	40	**54**	28	42	60	72	31	51	**49**
24	62	70	83	45	64	38	48	63	77	35	56	42	47	52	65	40	52	25
25	66	**71**	**87**	**52**	69.5	35	56	66	80	41	61	39	40	55	69	33	51	36
26	62	54	74	**52**	63	22	57	65	80	40	60	40	42	53	76	32	54	44
27	58	68	77	48	62.5	29	55	67	80	52	56	**49**	51	**45**	68	43	55	25
28	64	52	73	49	61	24	60	**72**	**83**	**54**	**68**	29	**36**	52	75	30	52	45
29	**51**	56	72	48	60	24	**63**	65	81	50	65	31	40	60	75	42	58	33
30	56	65	77	47	62	30	51	56	68	**54**	61	14	51	52				
31	61	**71**	82	47	64.5	35	58	56	78	46	62	32						
Sum .	1755	1930	2380	1472	1926	908	1747	1919	2345	1420	1883	926						
Mean	56.6	62.2	76.8	47.7	62.1	23.3	56.3	61.9	75.2	45.4	60.7	29.9						

TABLE I (Concluded).—*Temperature,* 1899.

	OCTOBER						NOVEMBER						DECEMBER					
Date	7 a.m.	7 p.m.	Max.	Min.	Mean	Range	7 a.m.	7 p.m.	Max.	Min.	Mean	Range	7 a.m.	7 p.m.	Max.	Min.	Mean	Range
1	58	57	72	42	56	30	22	31	47	19	33	28	35	41	48	28	38	20
2	34	35	49	31	40	18	15	36	52	13	28	39	23	12	23	11	17	12
3	27	39	53	22	37	31	27	31	50	23	37	27	3	20	27	—3	10	30
4	21	37	58	14	36	44	31	32	51	24	37	27	15	10	25	7	16	18
5	29	41	66	20	43	46	33	35	51	29	40	22	15	28	42	10	26	32
6	42	47	72	28	50	44	22	31	47	19	33	28	27	15	28	14	21	14
7	40	41	49	31	40	18	30	38	55	21	38	24	16	26	44	6	25	38
8	34	42	59	22	40	37	28	35	56	26	41	30	32	27	45	17	31	28
9	30	29	34	29	32	5	38	40	53	23	38	20	22	18	23	16	20	7
10	28	34	36	24	30	12	30	36	46	32	39	14	8	4	22	12	17	10
11	36	44	55	25	40	30	41	38	54	31	42	23	18	26	33	0	16	33
12	34	35	48	33	41	15	32	42	59	26	42	33	10	11	20	8	14	12
13	30	32	33	26	30	7	29	30	52	28	40	24	6	—2	17	0	9	17
14	26	37	39	22	30	17	33	35	58	27	43	31	13	7	22	—2	10	24
15	23	28	31	21	26	10	33	40	54	22	38	32	19	26	31	0	15	31
16	20	29	33	13	23	20	35	36	44	32	38	12	30	23	31	10	22	21
17	32	28	38	27	32	11	30	30	45	27	36	18	21	21	28	13	18	11
18	38	40	49	25	37	24	19	33	49	18	34	31	11	—9	19	—10	5	29
19	42	45	53	36	44	17	27	33	57	22	39	35	—6	—11	15	—13	1	28
20	49	51	58	40	49	18	24	26	43	17	30	26	—16	—9	15	—21	—3	36
21	34	50	64	33	48	31	26	38	52	16	34	36	—18	—7	14	—20	—3	34
22	44	40	63	43	53	20	19	27	38	16	27	22	—5	22	30	—17	6	47
23	47	37	57	34	46	23	26	21	39	22	31	17	21	16	33	7	20	26
24	34	32	34	27	30	7	15	30	42	12	27	30	20	35	41	14	28	27
25	12	31	35	8	22	27	11	29	42	11	26	31	24	34	44	16	30	28
26	29	30	43	24	34	19	13	23	45	9	27	36	23	30	38	18	28	20
27	26	34	47	23	35	24	26	33	48	19	34	29	25	16	21	13	20	14
28	31	37	54	27	40	27	41	44	50	30	40	20	23	27	38	15	26	23
29	39	36	57	29	43	28	39	34	58	21	30	37	31	27	43	16	30	21
30	39	44	58	29	44	29	28	30	37	27	32	10	27	32	40	15	21	25
31	38	32	43	32	37	11							20	21	31	18	25	13
Sum	1046	1172	1540	840	1290	700	832	997	1474	662	1070	792	504	537	932	198	535	724
Mean	33.8	37.0	50.1	27.4	40.8	22.5	27.7	33.2	49.1	22.1	35.7	26.2	16.4	17.3	30.1	6.4	17.2	23.3

TABLE II.—*Per Cent. of Saturation of the Air and Temperature of the Dew Point.*

Date	JANUARY						FEBRUARY						MARCH					
	RELATIVE HUMIDITY			DEW POINT			RELATIVE HUMIDITY			DEW POINT			RELATIVE HUMIDITY			DEW POINT		
	7 a m.	7 p.m.	Mean	7 a.m	7 p.m.	Mean	7 a.m.	7 p.m.	Mean	7 a.m.	7 p m.	Mean	7 a.m.	7 p m	Mean	7 a.m	7 p.m	Mean
1	54	**36**	45	6	9	7.5	**100**	**100**	**100**	3	7	5	65	66	65	19	20	19.5
2	48	91	69.5	15	**34**	24.5	**100**	78	89	13	5	9	64	**100**	82	18	24	21
3	87	81	84	21	9	15	**100**	**100**	**100**	6	3	4.5	83	91	87	12	7	9.5
4	**24**	47	35.5	**-14**	−1	**−7.5**	**100**	**100**	**100**	−4	9	2.5	82	82	82	11	11	11
5	60	58	59	1	0	.5	44	**100**	72	−24	−15	−19.5	74	71	73	−1	14	6.5
6	58	51	54.5	0	3	1.5	**42**	**100**	71	**−38**	**-16**	**-27**	75	35	55	20	12	16
7	84	72	78	15	15	15	**100**	78	89	13	5	9	45	57	51	18	25	21.5
8	81	84	82.5	10	14	12	82	84	83	11	15	13	**24**	**27**	**25**	15	25	20
9	47	78	62.5	1	25	13	**100**	87	93.5	10	21	15.5	53	39	46	25	20	22.5
10	27	40	**33**.5	−11	13	1	88	**100**	94	**23**	−12	5.5	85	**100**	92	18	11	15
11	74	**100**	87	17	24	20.5	**100**	64	82	−12	−10	−11	79	68	73	7	10	8.5
12	83	48	65.5	13	8	10.5	56	73	64.5	−16	16	0	68	51	59	10	12	11
13	60	81	70.5	1	10	5.5	71	83	77	14	12	13	69	47	58	11	14	12.5
14	41	40	40.5	2	7	4.5	79	83	81	7	13	10	**100**	47	74	16	**1**	8.5
15	57	76	66.5	9	21	15	74	**42**	**58**	19	9	14	83	59	71	12	21	16
16	68	**100**	84	23	28	**25.5**	60	60	60	11	11	11	66	66	66	26	27	26.5
17	86	**100**	93	19	12	15.5	**100**	87	93.5	10	22	16	**100**	**100**	**100**	23	9	16
18	74	64	69	17	18	17.5	**100**	63	81.5	12	17	14.5	**100**	56	78	3	17	10
19	**100**	**100**	**100**	**25**	22	23.5	66	54	60	21	22	21.5	56	42	49	17	15	16
20	74	76	75	17	21	19	63	57	60	17	9	13	79	60	70	27	23	25
21	67	50	58.5	21	22	21.5	82	81	81.5	11	12	11.5	**100**	86	93	27	19	23
22	58	**100**	79	11	12	11.5	**100**	54	77	3	−18	−7.5	57	76	67	9	21	15
23	**100**	47	73.5	−2	0	−1	57	63	60	9	16	12.5	90	54	72	31	26	28
24	57	**100**	78.5	9	11	10	66	**100**	83	15	20	17.5	75	68	71	**32**	**30**	**31**
25	61	59	60	13	20	16.5	**100**	**100**	**100**	0	1	.5	72	85	78	27	18	22.5
26	**100**	**100**	**100**	20	28	24	**100**	82	91	−1	11	5	**100**	**100**	**100**	2	2	2
27	84	75	79.5	14	20	17	60	**100**	80	13	21	17	**100**	**100**	**100**	**−10**	3	**−3.5**
28	80	**100**	90	7	0	3.5	71	90	80.5	14	**30**	**22**	83	77	80	13	22	17
29	74	88	81	17	23	20							58	88	73	19	25	22
30	86	**100**	93	20	20	20							**100**	**100**	**100**	17	8	12
31	85	54	69.5	18	15	16.5							**100**	73	86	−5	17	6
Sum .	2149	2213	2181	335	459	397	2274	2274	2274	161	236	198	2375	2171	2273	469	509	489
Mean	69.3	71.4	70.3	10.8	14.7	12.7	63.3	63.3	63.3	5.2	7.6	6.4	77	70	73.5	15	16	15.5

TABLE II (Continued).—*Per Cent. of Saturation of the Air and Temperature of the Dew Point.*

Date	APRIL						MAY						JUNE					
	RELATIVE HUMIDITY			DEW POINT			RELATIVE HUMIDITY			DEW POINT			RELATIVE HUMIDITY			DEW POINT		
	7 a.m.	7 p.m.	Mean	7 a.m.	7 p.m.	Mean	7 a.m.	7 p.m.	Mean	7 a.m.	7 p.m.	Mean	7 a.m.	7 p.m.	Mean	7 a.m.	7 p.m.	Mean
1	87	60	74	22	23	22.5	43	**91**	67	24	32	28	48	34	41	35	32	33.5
2	**100**	**100**	**100**	30	28	29	**100**	65	82	29	19	24	71	**84**	**77.5**	36	38	37
3	87	50	68	22	17	20	63	50	57	17	**17**	**17**	70	61	65.5	35	37	36
4	66	57	62	27	25	25	47	46	46	19	23	21	71	59	65	36	34	35
5	**100**	**100**	**100**	25	24	24.5	57	31	44	25	22	23	39	50	34.5	30	38	34
6	86	73	79	20	29	24.5	57	77	67	24	35	30	40	71	55.5	**22**	36	29
7	76	59	68	21	21	21	91	84	**88**	35	36	35	66	51	58.5	36	35	35.5
8	89	30	60	26	16	20	82	45	64	30	31	31	67	67	67	39	39	39
9	33	42	38	20	26	23	44	48	46	29	30	30	72	47	59.5	38	39	38.5
10	31	31	31	22	22	22	56	22	39	29	20	24.5	40	20	30	33	**26**	29.5
11	33	93	63	21	46	34	81	23	52	**47**	25	36	32	23	26.5	31	31	31
12	48	31	40	30	22	26	84	53	70	37	32	**34.5**	66	43	54.5	37	33	35
13	63	25	44	31	13	22	50	15	32	33	18	25.5	**100**	38	69	36	**26**	31
14	32	21	**27**	15	12	13.5	**11**	45	28	**—1**	36	17.5	76	38	57	34	33	33.5
15	42	24	33	15	16	15.5	16	**19**	**18**	16	18	**17**	55	32	43.5	35	31	33
16	28	26	**27**	21	21	21	40	37	38	22	20	21	40	27	33.5	32	33	32.5
17	38	20	28	**9**	**6**	**7.5**	42	22	32	23	20	21.5	37	18	27.5	36	30	33
18	37	42	39	20	26	23	44	22	33	29	23	26	44	19	31.5	38	31	34.5
19	38	76	56	10	21	12	29	85	57	25	**39**	32	**29**	33	31	36	38	37
20	88	26	57	25	8	16	83	52	68	33	24	28.5	37	58	47.5	41	**47**	44
21	**25**	30	**27**	11	23	17	73	61	67	29	20	29	39	20	29.5	30	**26**	**28**
22	46	**13**	30	27	9	18	76	59	67	33	33	33	36	62	49	28	38	33
23	42	22	32	26	23	24.5	49	34	42	31	32	31.5	72	47	59.5	**50**	39	**44.5**
24	66	55	61	**36**	**35**	**35.5**	51	20	36	34	23	28.5	61	56	58.5	45	42	43.5
25	64	28	46	34	20	27	33	23	28	30	27	28.5	48	24	36	41	34	37.5
26	63	30	46	31	16	24	48	34	41	30	28	29	53	25	39	38	30	34
27	36	74	55	17	30	23	85	46	60	40	27	33.5	41	23	32	38	31	34.5
28	**100**	**100**	**100**	29	27	28	46	26	36	27	21	24	40	32	36	36	38	37
29	88	**100**	94	25	28	26.5	32	**19**	25	26	22	24	31	**17**	**24**	36	31	33.5
30	**100**	58	79	32	26	29	50	34	46	34	25	29.5	42	18	30	44	29	36.5
31							42	33	37	26	29	27.5						
Sum	1828	1406	1662	690	660	674	1624	1311	1467	865	816	840.5	1563	1107	1380	1082	1025	1053.5
Mean	61	40	55.4	23	22	22.5	52	42	47	28	26	27	52.1	36.9	46	36	34.1	35.1

TABLE II (Continued).—*Per Cent. of Saturation of the Air and Temperature of the Dew Point.*

Date	JULY						AUGUST						SEPTEMBER					
	RELATIVE HUMIDITY			DEW POINT			RELATIVE HUMIDITY			DEW POINT			RELATIVE HUMIDITY			DEW POINT		
	7 a.m.	7 p.m.	Mean	7 a.m.	7 p.m.	Mean	7 a.m.	7 p.m.	Mean	7 a.m.	7 p.m.	Mean	7 a.m.	7 p.m.	Mean	7 a.m.	7 p.m.	Mean
1	73	65	69	51	44	47.5	43	82	63	41	51	46	57	46	52	44	41	43
2	62	76	69	46	47	46.5	72	34	53	49	39	44	45	50	47	44	44	44
3	65	75	70	44	45	44.5	71	**94**	82	48	53	50	62	26	44	**46**	37	41.5
4	41	40	40.5	38	41	39.5	**88**	82	87	**53**	51	**52**	51	56	54	35	51	43
5	54	33	43.5	46	38	42	61	53	57	45	42	43	29	76	52	31	**60**	**45.5**
6	47	82	64.5	43	51	47	57	72	65	44	49	47	27	14	**21**	27	27	27
7	67	69	68	47	**53**	50	63	42	52	47	39	43	65	**6**	36	43	**9**	**26**
8	60	29	44.5	50	36	43	60	36	48	43	39	41	79	81	80	42	45	43.5
9	40	31	35.5	41	37	39	46	48	47	37	41	39	**100**	34	67	40	26	33
10	51	45	48	45	45	45	40	28	34	36	35	35	40	48	44	24	42	33
11	62	63	62.5	46	49	47.5	38	30	34	33	36	35	26	17	22	25	23	24
12	65	60	62.5	53	50	**51.5**	40	43	41	36	41	38	50	32	41	33	35	34
13	60	72	66	50	49	49.5	52	49	51	41	47	44	30	**100**	65	34	48	41
14	82	66	74	49	43	46	49	19	34	42	28	35	73	53	63	41	38	39.5
15	76	**93**	**84.5**	46	49	47.5	47	51	49	43	45	44	**100**	79	**90**	44	40	42
16	65	63	64	43	47	45	58	76	67	47	46	46	84	72	78	37	38	37.5
17	77	64	70.5	49	51	50	65	39	52	44	40	42	64	34	49	24	39	32
18	83	56	69.5	52	49	50.5	60	74	67	42	**53**	48	84	43	63	35	35	35
19	73	23	48	51	35	43	40	22	31	33	25	29	83	35	59	34	28	31
20	30	29	29.5	38	38	38	42	17	30	31	24	28	62	15	39	31	20	25.5
21	40	33	36.5	41	40	40.5	**23**	22	22	29	28	28	31	24	27	25	26	25.5
22	45	39	42	45	43	44	33	23	28	23	29	26	60	22	41	29	25	27
23	35	18	26.5	48	28	38	34	26	30	25	27	26	49	68	58	27	49	33
24	**89**	**17**	53	**59**	**27**	43	38	**16**	27	27	**21**	24	30	42	36	23	32	27.5
25	**25**	26	**25.5**	**32**	38	35	22	**16**	**19**	**22**	22	**22**	69	35	52	31	32	31.5
26	34	88	61	36	50	43	30	18	24	29	25	27	56	23	40	29	23	26
27	78	30	54	52	38	45	49	29	39	36	36	36	30	50	40	26	29	27.5
28	45	81	63	44	46	45	26	26	26	28	38	33	66	23	44	27	21	24
29	81	60	70.5	46	43	44.5	44	45	44	42	44	43	38	11	25	**22**	19	**20.5**
30	60	41	50.5	43	43	43	72	77	75	49	49	49	**24**	21	22	23	21	22
31	46	16	31	42	**27**	**34.5**	62	38	50	46	33	40						
Sum	1811	1583	1697	1416	1320	1368	1525	1327	1425	1191	1176	1183	1651	1236	1448	986	994	991
Mean	58.4	51.1	54.7	45.6	42.6	44.1	49.2	42.7	46.1	38.4	37.9	38.1	55.3	41.5	48	32.9	33.1	33

TABLE II (Concluded).—*Per Cent. of Saturation of the Air and Temperature of the Dew Point.*

Date	OCTOBER						NOVEMBER						DECEMBER					
	RELATIVE HUMIDITY			DEW POINT			RELATIVE HUMIDITY			DEW POINT			RELATIVE HUMIDITY			DEW POINT		
	7 a.m.	7 p.m.	Mean	7 a.m.	7 p.m.	Mean	7 a.m.	7 p.m.	Mean	7 a.m.	7 p.m.	Mean	7 a.m.	7 p.m.	Mean	7 a.m.	7 p.m.	Mean
1	29	24	26.5	31	26	28.5	73	40	56.5	16	15	15.5	47	**34**	**40.5**	21	20	20.5
2	**100**	47	73.5	**34**	21	27.5	83	57	70	12	25	18.5	**100**	81	90.5	23	9	16
3	77	45	61	22	23	22.5	77	80	78.5	22	27	24.5	73	43	58	1	6	2.5
4	86	18	52	19	**7**	**13**	**100**	51	75.5	31	20	25.5	66	58	62	8	1	4.5
5	47	30	38.5	15	11	**13**	53	56	54.5	20	24	22	32	56	44	-3	17	7
6	**22**	**13**	**22.5**	15	12	13.5	73	**21**	47	16	**6**	11	65	66	65.5	19	8	13.5
7	38	62	50	22	31	26.5	58	36	47	20	19	19.5	67	53	60	10	15	12.5
8	73	63	68	27	32	29.5	66	30	48	21	14	15.5	**24**	65	44.5	8	19	13.5
9	**100**	**100**	**100**	30	29	29.5	28	54	41	15	27	21	**100**	**100**	**100**	22	18	20
10	77	**100**	88.5	23	**34**	28.5	**100**	70	**85**	**39**	**30**	**34.5**	**100**	74	87	8	0	4
11	82	64	73	32	**34**	**33**	55	59	57	28	28	28	69	88	79.5	11	23	17
12	91	73	82	32	29	30.5	60	42	46	23	24	23.5	58	60	59	1	2	1.5
13	**100**	**100**	**100**	30	32	31	57	38	47.5	19	13	16	76	66	71	1	—8	3.5
14	53	67	60	15	28	21.5	**26**	22	**24**	11	10	10.5	45	53	49	0	—3	1.5
15	48	88	68	**10**	34	17	44	46	45	18	25	21.5	41	76	58.5	4	21	12.5
16	85	57	71	18	19	18.5	54	48	51	24	22	23	89	**100**	94.5	27	23	25
17	70	77	73.5	25	23	24	68	58	63	23	20	21.5	**100**	86	93	21	19	20
18	68	69	68.5	29	31	30	56	35	45.5	10	14	12	80	52	66	7	-17	-5
19	56	46	51	29	28	28.5	43	26	34.5	12	11	11.5	58	48	53	13	**-21**	-17
20	28	24	26	23	23	23	62	65	63.5	16	18	17	32	52	42	28	17	22.5
21	65	27	46	26	24	25	76	52	64	21	24	22.5	26	56	41	**33**	15	**24**
22	38	69	53.5	24	31	27.5	70	54	62	13	16	14.5	75	**34**	54.5	9	4	—2.5
23	24	50	37	20	24	22	63	**73**	68	18	15	16.5	72	51	61.5	15	5	10
24	54	**100**	77	22	32	27	83	58	70.5	12	20	16	57	66	62.5	19	**26**	**22.5**
25	**100**	**100**	**100**	12	31	21.5	80	56	68	**8**	19	13.5	50	45	47.5	12	19	15.5
26	78	68	73	25	23	24	81	48	59.5	10	10	**10**	74	79	76.5	17	**26**	21.5
27	78	65	71.5	21	26	23.5	64	72	68	18	26	22	51	67	59	14	10	12
28	69	58	63.5	24	26	25	48	44	46	26	27	26.5	48	77	62.5	10	22	11
29	45	48	46.5	23	22	27.5	53	45	49	26	19	22.5	59	65	62	21	19	20
30	30	51	40.5	17	29	23	56	38	47	17	13	15	78	51	64.5	**25**	20	**22.5**
31	44	70	57	22	25	23.5							71	58	64.5	14	11	12.5
Sum	1963	1873	1918	717	790	735.3	1910	1474	1692	565	582	573.5	1983	1960	1471.5	251	282	266.5
Mean	63.3	60.4	61.8	23.1	25.5	24.3	63.7	49.1	56.4	18.8	19.4	19.1	63.9	63.2	63.5	8.1	9.1	8.6

TABLE III.—*Weekly Means of Soil Temperatures.*

WEEK ENDING	Air Temp.	DEPTH					
		3 Inches	6 Inches	12 Inches	24 Inches	36 Inches	72 Inches
January 6	17.4	17.7	18.4	22.0	24.6	27.9	35.2
January 13	18.6	19.0	20.0	22.0	23.8	27.0	35.0
January 20	22.8	24.3	23.8	24.8	25.4	27.4	34.0
January 27	20.0	25.9	23.5	25.4	26.5	28.9	34.0
February 3	12.8	23.5	23.6	25.7	27.0	29.0	34.0
February 10	1.9	15.2	16.4	20.9	24.1	28.2	34.0
February 17	12.8	19.0	19.0	21.1	23.9	27.1	33.6
February 24	17.9	26.0	22.6	24.6	25.8	27.4	32.9
March 3	17.0	24.7	24.3	26.0	26.5	28.1	32.5
March 10	26.0	27.0	26.6	27.8	28.2	29.3	32.5
March 17	20.7	26.5	26.5	28.4	29.0	30.0	33.0
March 24	25.3	31.3	30.2	30.7	30 4	31.2	33.0
March 31	15.0	30.2	30.0	31.6	31.4	32.0	33.3
April 7	28.7	32.0	32.3	33.0	32.1	32.5	34.0
April 14	42.6	41.2	41.7	40.4	35.7	35.3	34.0
April 21	37.0	42.0	43.0	43.5	40.9	39.1	35.2
April 28	43.1	48.1	47.2	47.2	44.5	42.2	37.0
May 5	33.4	39.5	39.3	41.1	41.2	42.3	38.7
May 12	44.4	46.1	45.7	45.3	43.1	42.0	39.0
May 19	49.5	51.8	51.0	52.3	47.6	46.0	39.5
May 26	47.3	49.9	49.5	49.7	48.2	47.3	41.5
June 2	48.7	52.8	52.0	52.7	51.0	49.1	43.0
June 9	48.0	50.5	42.6	49.8	49.2	48.9	43.4
June 16	53.5	58.5	57.4	56.4	53.0	51.0	44.0
June 23	61.0	65.2	63.7	62.6	58.8	55.2	45.8
June 30	63.5	67.8	66.3	65.1	61.6	58.5	48.0
July 7	58.0	63.3	63.5	64.4	62.4	60.3	49.7
July 14	61.6	65.5	64.7	65.0	62.5	60.5	51.1
July 21	61.0	64.0	63.4	63.7	61.1	59.7	52.0
July 28	62.7	64.9	67.4	67.1	64.7	62.3	52.0
August 4	58.9	65.1	64.4	65.0	63.1	62.0	53.0
August 11	59.4	63.1	63.4	63.4	61.8	61.0	54.0
August 18	59.4	67.0	65.5	65.3	63.0	61.3	54.0
August 25	58.0	65.9	65.3	65.0	63.0	62.0	54.0
September 1	60.8	67.9	66.1	65.7	63.7	62.0	55.0
September 8	58.5	66.2	65.5	65.7	64.1	62.0	55.1
September 15	50.3	63.0	62.6	63.0	62.0	61.3	55.0
September 22	47.6	59.4	58.3	59.0	58.5	58.7	55.0
September 29	48.0	60.6	59.0	58.7	57.7	57.0	54.0
October 6	40.7	54.0	53.7	55.2	55.3	56.0	53.3
October 13	35.0	43.0	45.0	49.0	50.3	52.3	52.3
October 20	34.7	38.0	37.5	40.8	43.1	47.0	50.7
October 27	34.0	33.3	39.5	42.0	43.0	45.0	49.0
November 3	32.0	39.0	38.0	40.1	40.7	43.3	47.0
November 10	33.0	38.0	37.0	39.0	42.0	42.0	46.1
November 17	34.1	38.0	37.0	39.2	39.3	41.0	45.0
November 24	26.0	34.4	34.1	36.0	37.1	40.2	44.0
December 1	30.5	34.0	33.0	34.8	35.0	38.1	43.0
December 8	19.2	29.8	30.3	33.4	34.5	37.2	41.5
December 15	13.3	26.8	27.0	30.5	32.3	35 0	40.5
December 22	3.3	21.8	23.5	28.0	30.1	34.0	39.9
December 29	25.7	25.7	24.7	27.0	28.5	32.0	39.0
Sums	1934.6	2247.4	2220.0	2296.1	2272.3	2296.1	2245.3
Means	37.2	43.2	42.7	44.1	43.7	44.1	43.2

TABLE IV.—*Atmospheric Pressure.*

Date	JANUARY			FEBRUARY			MARCH			APRIL		
	7 a. m.	7 p. m.	Mean	7 a. m.	7 p. m.	Mean	7 a. m.	7 p. m.	Mean	7 a. m.	7 p. m.	Mean
1	23.024	22.774	22.899	22.588	22.568	22.578	22.732	22.802	22.767	22.956	22.876	22.916
2	22.794	22.734	22.764	22.560	**22.500**	**22.530**	22.806	22.870	22.838	22.842	22.946	22.894
3	**22.634**	22.812	22.723	**22.503**	22.712	22.607	22.882	23.082	22.982	23.130	23.182	23.156
4	22.816	22.910	22.863	22.648	22.714	22.681	23.026	**23.140**	23.083	23.086	22.988	23.037
5	22.886	22.978	22.932	22.748	22.796	22.772	**23.222**	23.126	**23.174**	23.000	23.190	23.095
6	23.038	23.102	23.070	22.784	22.866	22.825	23.128	**23.140**	23.134	23.192	23.142	23.167
7	23.020	22.984	23.002	22.896	22.790	22.843	23.116	23.086	23.101	23.296	**23.330**	**23.313**
8	22.950	22.988	22.969	22.802	22.830	22.816	23.022	23.070	23.046	23.286	23.226	23.256
9	23.026	23.078	23.052	22.874	22.901	22.887	22.892	22.764	22.828	23.164	23.036	23.100
10	22.936	22.880	22.908	22.792	23.000	22.896	22.630	22.924	22.777	22.932	22.930	22.931
11	22.738	22.668	22.703	23.091	**23.228**	23.159	22.898	22.918	22.908	23.030	23.106	23.068
12	22.788	22.944	22.866	**23.226**	23.020	23.123	22.896	22.878	22.887	23.076	22.942	23.009
13	22.982	23.044	23.013	22.938	23.061	22.999	22.782	22.692	22.737	22.926	23.056	22.991
14	23.048	22.974	23.011	23.026	23.068	23.047	22.708	22.967	22.838	23.150	23.218	23.184
15	22.904	22.900	22.902	22.976	22.966	22.971	23.016	22.998	23.007	**23.354**	23.226	23.290
16	22.850	23.080	22.965	22.992	23.032	23.012	22.952	22.898	22.925	23.058	22.794	22.926
17	23.122	**23.200**	23.161	23.076	23.010	23.043	22.712	22.828	22.770	22.876	22.958	22.917
18	23.168	23.162	23.165	23.218	23.182	**23.200**	22.820	22.994	22.907	22.892	**22.784**	22.838
19	23.160	23.138	23.149	23.086	23.020	23.053	22.994	22.886	22.940	22.918	23.142	23.030
20	23.118	23.208	23.163	22.882	22.872	22.877	22.722	22.728	22.725	23.206	23.206	23.206
21	23.218	23.024	23.121	22.768	22.782	22.775	22.700	22.766	22.733	23.250	23.176	23.213
22	22.916	23.128	23.022	22.868	23.112	22.990	22.826	22.940	22.883	23.078	22.978	23.028
23	**23.266**	23.108	**23.187**	22.984	22.892	22.938	22.904	23.000	22.952	23.026	23.034	23.030
24	22.976	23.030	23.003	22.620	22.642	22.631	22.890	22.916	22.903	23.086	23.056	23.071
25	22.868	22.866	22.867	22.614	22.698	22.656	22.864	22.792	22.828	23.076	22.900	22.983
26	22.934	22.814	22.874	22.700	22.760	22.780	22.818	22.900	22.859	22.962	22.864	22.913
27	23.130	22.792	22.961	22.726	22.758	22.742	22.892	22.870	22.881	22.782	22.790	**22.786**
28	22.868	22.928	22.903	22.780	22.714	22.747	22.801	22.798	22.800	**22.728**	22.940	22.834
29	22.816	22.750	22.783				**22.604**	**22.572**	**22.588**	22.942	22.882	22.912
30	**22.634**	22.746	22.690				22.662	22.900	22.781	22.802	22.862	22.832
31	22.700	**22.442**	**22.571**				22.916	22.964	22.940			
Sum. . . .	711.328	711.186	711.257	639.776	640.402	640.134	708.863	710.200	709.530	691.102	690.750	690.931
Mean . .	22.946	22.942	22.944	22.849	22.874	22.862	22.866	22.910	22.887	23.037	23.025	23.031

TABLE IV (Continued).—*Atmospheric Pressure.*

Date	MAY			JUNE			JULY			AUGUST		
	7 a. m.	7 p. m.	Mean	7 a. m.	7 p. m.	Mean	7 a. m.	7 p. m.	Mean	7 a. m.	7 p. m.	Mean
1	22.822	**22.712**	**22.767**	22.942	22.864	22.903	23.372	23.278	23.325	23.238	23.270	23.254
2	**22.694**	22.854	22.774	22.918	22.870	22.894	23.288	23.240	23.264	23.232	23.268	23.250
3	22.942	23.002	22.972	**22.814**	22.890	22.852	23.234	23.160	23.197	23.278	23.210	23.244
4	23.088	23.078	23.083	22.848	22.866	22.857	23.198	23.152	23.175	23.196	23.186	23.191
5	23.026	23.002	23.014	22.880	**22.800**	**22.840**	23.176	23.176	23.176	23.222	23.224	23.223
6	23.094	23.054	23.074	22.992	23.044	23.018	23.260	23.292	23.276	23.270	23.214	23.242
7	23.158	**23.274**	**23.216**	23.150	23.182	23.166	23.338	23.326	23.332	23.190	23.150	23.170
8	**23.238**	23.100	23.169	23.238	23.260	23.249	23.336	23.314	23.325	23.190	23.160	23.175
9	22.990	23.028	23.009	23.284	23.024	23.154	23.376	23.336	23.356	23.218	23.182	23.200
10	23.180	23.174	23.177	23.218	23.090	23.154	23.378	23.318	23.348	23.160	23.124	23.142
11	23.180	23.030	23.105	23.042	22.898	22.970	23.342	23.278	23.310	23 202	23.170	23.186
12	23.088	23.160	23.124	22.954	22.950	22.952	23.336	23.336	23.336	23.202	23.154	23.178
13	23.030	22.952	22.991	23.008	23.132	23.070	23.374	23.286	23.330	23.220	23.152	23.186
14	23.004	22.942	22.973	23.320	23.310	23.315	23.268	23.222	23.245	23.176	23.132	23.154
15	22.868	22.860	22.864	23.402	23.386	23.394	23.280	23.292	23.286	23.228	23.234	23.231
16	22.992	23.040	23.016	23.178	**23.438**	23.308	23.368	23.360	23.364	23.180	23.106	23.143
17	23.152	23.066	23.109	**23.480**	23.376	**23.428**	**23.432**	**23.370**	**23.401**	23.128	23.066	23.097
18	23.084	23.010	23.047	23.420	23.360	23.390	23.410	23.334	23.372	23.132	23.060	23.096
19	23.028	22.936	22.982	23.318	23.268	23.293	23.300	23.192	23.246	23.088	23.182	23.135
20	22.892	22.836	22.864	23.220	23.074	23.147	23.220	23.162	23.191	23.280	23.136	23.208
21	22.872	23.040	22.956	23.226	23.168	23.197	23.186	23.152	23.169	**23.114**	**23.002**	**23.058**
22	23.108	23.168	23.138	23.000	23.326	23.163	23.208	23.176	23.192	23.168	23.110	23.139
23	23.190	23.166	23.178	23.262	23.228	23.245	23.284	23.278	23.281	23.264	**23.278**	23.271
24	23.190	23.102	23.146	23.258	23.214	23.236	23.334	23.270	23.302	23.292	23.200	23.246
25	23.092	22.982	23.037	23.216	23.090	23.153	23.306	23.270	23.288	23.180	23.112	23.146
26	23.040	22.998	23.019	23.110	23.166	23.138	23.324	23.330	23.327	23.164	23.168	23.166
27	22.996	22.988	22.992	23.358	23.344	23.351	23.284	23.220	23.252	23.230	23.228	23.229
28	23 040	23.072	23.056	23.444	23.352	23.398	23.266	23.260	23.263	**23.330**	23.268	**23.299**
29	23.084	22.944	23.014	23.422	23.346	23.384	23.294	23.260	23.277	23.320	23.232	23.276
30	22.932	22.992	22.962	23.358	23.266	23.312	23.218	23.126	23.172	23.276	23.222	23.249
31	23.064	23.002	23.033				**23.156**	**23.116**	**23.136**	23.230	23.200	23.215
Sum. . . .	714.158	713.564	713.861	695.280	694.572	694.926	722.146	720.882	721.514	719.598	718.400	718.999
Mean . . .	23.037	23.018	23.027	23.176	23.152	23.164	23.297	23.254	23.275	23.212	23.174	23.193

TABLE IV (Concluded).—*Atmospheric Pressure.*

Date	SEPTEMBER			OCTOBER			NOVEMBER			DECEMBER		
	7 a. m.	7 p. m.	Mean	7 a. m.	7 p. m.	Mean	7 a. m.	7 p. m.	Mean	7 a. m.	7 p. m.	Mean
1	23.188	23.212	23.200	23.012	22.932	22.972	**23.412**	**23.384**	**23.398**	23.098	22.988	23.043
2	23.296	23.288	23.292	23.178	23.322	23.250	23.352	23.264	23.308	22.942	23.192	23.067
3	23.212	**23.092**	23.152	23.340	23.368	23.354	23.224	23.218	23.221	23.154	23.102	23.128
4	23.138	23.100	23.119	**23.444**	**23.442**	**23.443**	23.182	23.148	23.165	23.108	23.068	23.088
5	23.162	23.140	23.151	23.412	23.362	23.387	23.170	23.184	23.177	23.022	22.968	22.995
6	23.196	23.224	23.210	23.332	23.202	23.267	23.250	23.276	23.263	22.992	23.164	23.078
7	23.262	23.204	23.233	23.196	23.300	23.248	23.258	23.252	23.255	23.196	23.100	23 148
8	23.292	23.262	23.277	23.162	22.932	23.047	23.268	23.250	23.259	22.936	22.832	22.884
9	23.278	23.288	23.283	22.892	22.876	22.884	23.148	23.128	23.138	**22.806**	22.972	22.889
10	23.436	23.412	23.424	22.818	**22.778**	**22.798**	23.118	23.132	23.125	23.042	23.022	23.032
11	23.448	23.396	23.422	**22.788**	22.848	22.819	23.112	23.138	23.125	22.884	**22.702**	**22.793**
12	23.396	23.234	23.315	22.812	22.984	22.898	23 124	23.084	23.104	22.818	22.902	22.860
13	23.200	23.212	23.206	23.076	23.058	23.067	23.196	23.274	23.235	22.934	23.014	22.974
14	23.104	23.096	23.100	22.942	22.838	22.890	23.246	23.218	23.232	23.150	23.094	23.122
15	**23.052**	23.136	**23.094**	22.818	22.916	22.867	23.092	22.810	22.951	22.996	22.864	22.930
16	23.262	23.292	23.277	23.048	22.972	23.010	**22.814**	22.922	22.868	22.812	22.844	22.828
17	23.278	23.282	23.280	22.872	22.960	22.916	23.042	23.138	23.090	22.828	22.922	22.875
18	23.362	23.328	23.345	22.938	22.996	22.967	23.138	23.082	23.110	23.154	23.334	23.244
19	23.408	23.400	23.404	23.162	23.200	23.181	22.982	22.842	22.912	**23.438**	**23.450**	**23 444**
20	23.382	23.342	23.362	23.226	23.222	23.224	23.004	23.062	23.033	23.400	23.362	23.381
21	23.328	23.262	23.295	23.196	23.124	23.160	22.924	22.814	22.869	23 324	23.268	23.296
22	23.284	23.282	23.283	23.068	23.036	23.052	22.824	22.972	22.898	23.300	23.242	23.271
23	23.366	23.352	23.359	22.932	23.018	22.975	23.176	23.262	23.219	23.240	23.276	23.258
24	23.400	**23.456**	23.428	23.084	23.182	23.133	23.254	23.192	23.223	23.164	23.120	23.142
25	**23.502**	23.418	**23.460**	23.252	23.312	23.282	23.162	23.162	23.162	23.034	22.972	23.003
26	23.382	23.262	23.322	23.284	23.258	23.271	23.156	23.142	23.149	22.900	22.874	22.887
27	23.212	23.306	23.259	23.284	23.286	23.285	23.152	23.158	23.155	22.928	22.982	22.955
28	23.338	23.316	23.327	23.290	23.282	23.286	23.086	23.064	23.075	23.094	23.212	23.153
29	23.300	23.218	23.259	23.246	23.192	23.219	22.912	**22.752**	**22.832**	23.152	23.032	23.092
30	23.180	23.112	23.146	23.156	23.066	23.111	23 022	23.102	23.062	22.934	22.866	22.900
31				23.078	23.326	23.202				22.906	22.992	22.949
Sum . . .	698.644	697.924	698.284	716.338	716.500	716.464	693.800	693.427	693.614	714.686	714.732	714.709
Mean . . .	23.288	23.264	23.276	23.104	23.116	23.110	23.127	23.111	23.119	23.054	23.056	23.055

TABLE V.—*Wind Record.*

JANUARY							FEBRUARY						
Date	DIRECTION FROM			Daily distance in miles	Greatest number miles in one hour of day	Maximum velocity in miles per hour	Date	DIRECTION FROM			Daily distance in miles	Greatest number miles in one hour of day	Maximum velocity in miles per hour
	7 a. m.	Noon	7 p. m.					7 a. m.	Noon	7 p. m.			
1	sw	sw	w	304	26	38	1	nw	n	w	300	34	39
2	sw	sw	sw	502	39	42	2	n	w	se	112	12	14
3	sw	sw	w	480	34	48	3	s	ne	w	252	23	29
4	w	w	sw	544	41	46	4	n	nw	nw	278	16	21
5	sw	w	w	530	38	47	5	n	n	n	274	21	26
6	w	w	w	670	40	48	6	s	nw	sw	145	14	23
7	sw	sw	w	390	38	40	7	sw	w	w	253	18	25
8	s	n	s	270	23	27	8	nw	nw	n	439	29	37
9	s	sw	s	208	13	18	9	nw	w	w	361	30	33
10	se	sw	sw	265	26	30	10	w	w	s	420	29	35
11	n	sw	sw	320	28	31	11	n	n	se	250	31	34
12	sw	w	sw	420	27	33	12	s	s	se	194	10	14
13	sw	sw	s	370	23	28	13	s	w	e	395	25	33
14	sw	sw	sw	480	37	43	14	w	sw	nw	253	19	25
15	sw	sw	sw	550	32	38	15	s	sw	sw	430	32	38
16	w	nw	n	525	30	40	16	sw	nw	nw	340	24	31
17	ne	e	e	280	32	37	17	w	w	w	290	23	29
18	sw	sw	sw	240	17	23	18	se	n	sw	220	20	27
19	sw	n	se	420	25	30	19	w	sw	sw	490	27	32
20	w	n	sw	261	23	27	20	w	w	w	487	31	37
21	sw	sw	sw	520	32	39	21	w	w	nw	590	39	45
22	w	nw	nw	608	34	41	22	nw	nw	s	341	32	41
23	w	sw	sw	354	35	37	23	w	sw	s	338	38	46
24	sw	sw	sw	440	26	33	24	e	n	nw	275	27	35
25	sw	w	w	481	31	36	25	s	s	s	238	25	33
26	sw	w	nw	303	29	35	26	s	w	w	130	22	31
27	nw	w	w	405	27	37	27	s	sw	w	540	40	47
28	ne	nw	s	522	36	43	28	sw	sw	w	530	47	50
29	w	w	w	230	26	31							
30	w	w	w	495	33	36							
31	w	sw	w	310	32	40							
Sum				12787			Sum				9165		
Daily mean.				412.5			Daily mean.				327.3		
Hourly mean.				17.2			Hourly mean.				13.7		

TABLE V (Continued).—*Wind Record.*

MARCH							APRIL						
	DIRECTION FROM							DIRECTION FROM					
Date	7 a. m.	Noon	7 p. m.	Daily distance in miles	Greatest number miles in one hour of day	Maximum velocity in miles per hour	Date	7 a. m.	Noon	7 p. m.	Daily distance in miles	Greatest number miles in one hour of day	Maximum velocity in miles per hour
1	sw	w	w	560	34	37	1	ne	se	sw	170	21	36
2	nw	w	sw	368	20	29	2	n	sw	sw	323	23	[illegible]
3	n	nw	n	209	18	25	3	nw	sw	sw	256	25	33
4	w	w	w	400	28	33	4	sw	sw	sw	463	35	42
5	nw	w	s	455	32	37	5	n	n	nw	377	37	38
6	s	w	sw	360	30	38	6	s	w	w	292	33	[illegible]
7	sw	sw	sw	560	36	40	7	nw	nw	se	479	37	[illegible]
8	w	w	se	344	27	33	8	nw	w	s	246	26	30
9	sw	sw	s	360	28	37	9	se	sw	sw	225	18	35
10	ne	nw	nw	456	30	38	10	sw	sw	w	413	26	36
11	nw	nw	w	545	33	37	11	sw	w	s	447	30	35
12	sw	sw	sw	442	33	39	12	sw	sw	sw	413	26	[illegible]
13	s	s	se	346	22	25	13	w	w	w	453	26	31
14	ne	w	n	330	19	24	14	s	nw	w	434	32	[illegible]
15	e	sw	sw	365	30	38	15	s	nw	se	234	19	35
16	s	sw	sw	350	20	32	16	se	sw	sw	341	33	[illegible]
17	e	e	nw	258	25	31	17	w	w	w	743	38	43
18	ne	se	sw	150	17	25	18	s	sw	nw	380	25	39
19	sw	sw	sw	430	28	37	19	w	w	nw	635	33	[illegible]
20	s	sw	sw	433	26	28	20	nw	nw	s	623	37	46
21	sw	w	w	380	19	23	21	s	nw	e	298	34	31
22	w	w	sw	610	31	37	22	sw	s	se	225	11	35
23	sw	w	sw	400	34	38	23	s	sw	e	348	27	33
24	sw	w	w	420	30	36	24	n	n	se	393	32	[illegible]
25	sw	e	e	490	37	43	25	sw	e	se	359	34	39
26	e	e	e	620	32	30	26	n	w	w	378	31	39
27	e	e	nw	260	24	31	27	w	w	nw	371	41	[illegible]
28	w	w	sw	330	25	30	28	nw	nw	s	377	30	35
29	w	e	s	370	27	35	29	se	se	se	394	29	33
30	nw	nw	ne	330	24	32	30	e	nw	w	413	26	[illegible]
31	nw	n	ne	180	17	24							
Sum				12111			Sum				11493		
Daily mean				390.7			Daily mean				383.1		
Hourly mean				16.2			Hourly mean				15.9		

TABLE V (Continued)—*Wind Record.*

MAY							JUNE						
Date	DIRECTION FROM			Daily distance in miles	Greatest number miles in one hour of day	Maximum velocity in miles per hour	Date	DIRECTION FROM			Daily distance in miles	Greatest number miles in one hour of day	Maximum velocity in miles per hour
	7 a. m.	Noon	7 p. m.					7 a. m.	Noon	7 p. m.			
1	se	se	n	385	34	37	1	se	se	w	401	30	38
2	nw	nw	nw	354	24	32	2	n	n	sw	326	26	31
3	nw	w	w	666	39	45	3	sw	sw	w	336	24	29
4	sw	sw	se	447	28	35	4	w	w	nw	378	22	28
5	s	w	nw	294	19	27	5	w	sw	se	474	**35**	**40**
6	s	se	s	204	20	29	6	w	n	s	469	33	**40**
7	n	ne	se	267	28	34	7	s	sw	sw	222	18	24
8	s	sw	sw	183	17	25	8	e	ne	ne	334	23	32
9	sw	w	w	258	19	27	9	s	ne	ne	285	21	25
10	sw	w	w	321	18	27	10	sw	w	w	244	20	26
11	sw	w	w	457	29	36	11	sw	sw	sw	**482**	29	33
12	nw	n	se	463	27	32	12	nw	nw	n	417	29	35
13	s	sw	sw	443	42	47	13	n	nw	nw	278	20	24
14	s	sw	se	461	34	39	14	n	ne	ne	300	28	30
15	se	sw	sw	538	35	44	15	n	n	n	**165**	**9**	**13**
16	n	se	w	454	37	45	16	se	nw	w	233	20	25
17	s	sw	ne	322	40	47	17	se	nw	nw	234	11	15
18	ne	se	s	381	27	34	18	se	nw	nw	244	17	23
19	e	se	se	227	18	**23**	19	se	nw	sw	257	20	27
20	nw	nw	w	358	34	41	20	s	sw	se	361	25	30
21	sw	sw	ne	**744**	**47**	**58**	21	sw	w	ne	342	24	28
22	se	w	nw	313	32	44	22	se	ne	e	278	27	34
23	s	w	s	283	20	25	23	se	nw	nw	462	29	35
24	se	sw	sw	**174**	**11**	**23**	24	sw	se	sw	314	34	37
25	se	sw	s	309	34	42	25	sw	se	sw	339	26	38
26	n	sw	w	369	36	50	26	sw	sw	sw	351	21	25
27	s	sw	w	278	24	26	27	sw	w	se	249	16	22
28	w	w	w	429	33	42	28	e	nw	e	264	17	19
29	s	sw	se	311	25	30	29	w	w	sw	247	24	27
30	w	w	w	405	34	37	30	s	w	nw	237	16	24
31	se	w	se	352	37	45							
Sum				11481			Sum				9523		
Daily mean				370.3			Daily mean				317.5		
Hourly mean				15.4			Hourly mean				13.2		

TABLE V (Continued).—*Wind Record,*

JULY						
Date	DIRECTION FROM 7 a. m.	DIRECTION FROM Noon	DIRECTION FROM 7 p. m.	Daily distance in miles	Greatest number miles in one hour of day	Maximum velocity in miles per hour
1	e	e	se	471	33	27
2	e	nw	se	210	27	32
3	e	nw	sw	400	20	34
4	se	ne	sw	322	31	40
5	se	w	nw	343	22	27
6	se	ne	e	274	29	35
7	e	e	e	313	28	36
8	s	nw	e	406	26	30
9	e	se	e	278	24	29
10	w	se	.se	212	28	33
11	se	nw	w	164	19	25
12	n	w	nw	192	22	28
13	e	se	e	216	18	27
14	e	ne	nw	172	30	36
15	s	ne	ne	190	24	29
16	e	e	se	152	11	14
17	s	nw	se	219	22	26
18	ne	ne	ne	194	19	23
19	s	nw	ne	186	13	17
20	s	ne	se	166	18	22
21	s	nw	sw	279	17	24
22	ne	se	se	286	21	25
23	ne	n	nw	216	20	26
24	e	w	w	288	22	27
25	e	nw	nw	206	18	23
26	se	se	nw	422	27	32
27	se	se	nw	236	32	40
28	s	sw	ne	273	31	36
29	se	s	sw	234	23	25
30	s	se	sw	359	22	28
31	sw	sw	w	341	23	30
Sum				8220		
Daily mean				265.1		
Hourly mean				11		

AUGUST						
Date	DIRECTION FROM 7 a. m.	DIRECTION FROM Noon	DIRECTION FROM 7 p. m.	Daily distance in miles	Greatest number miles in one hour of day	Maximum velocity in miles per hour
1	se	se	sw	414	35	[illegible]
2	sw	nw	nw	205	11	17
3	e	se	ne	192	16	30
4	se	ne	s	117	11	14
5	s	w	sw	272	19	23
6	s	se	ne	212	20	24
7	sw	sw	sw	327	29	35
8	s	sw	w	276	17	35
9	sw	sw	sw	285	22	27
10	se	w	w	294	23	33
11	se	se	s	310	16	21
12	sw	sw	sw	299	20	27
13	se	e	s	168	14	30
14	s	sw	se	461	27	34
15	s	sw	sw	382	18	[illegible]
16	sw	sw	s	263	24	35
17	sw	sw	s	234	19	36
18	se	sw	s	325	29	33
19	w	w	w	406	30	35
20	e	se	ne	287	17	25
21	sw	sw	sw	508	22	35
22	sw	sw	sw	370	25	34
23	se	w	w	379	21	36
24	s	w	w	218	14	21
25	e	sw	sw	296	22	29
26	se	sw	sw	287	20	25
27	ne	w	w	216	19	34
28	w	w	ne	241	17	23
29	w	nw	e	279	20	34
30	e	nw	se	195	21	36
31	se	nw	nw	177	16	22
Sum				8885		
Daily mean				286.6		
Hourly mean				11.9		

TABLE V (Continued).—*Wind Record.*

SEPTEMBER

Date	DIRECTION FROM			Daily distance in miles	Greatest number miles in one hour of day	Maximum velocity in miles per hour
	7 a. m.	Noon	7 p. m.			
1	s	s	s	295	24	27
2	se	se	se	280	23	30
3	s	s	s	401	28	32
4	se	sw	s	232	20	27
5	nw	s	s	327	27	34
6	e	sw	e	226	22	26
7	e	s	s	442	36	32
8	se	se	se	446	29	34
9	s	nw	nw	258	21	26
10	s	nw	sw	127	15	15
11	se	nw	n	191	15	19
12	sw	se	se	255	21	27
13	se	w	sw	343	35	46
14	e	e	se	234	23	26
15	sw	nw	n	312	21	25
16	ne	s	se	214	19	22
17	se	nw	n	285	20	25
18	s	nw	ne	304	24	30
19	s	se	e	139	13	16
20	se	sw	n	276	23	25
21	se	w	nw	262	22	26
22	se	nw	se	157	16	22
23	s	nw	w	200	17	23
24	se	nw	n	286	24	29
25	se	nw	e	148	8	12
26	se	nw	nw	217	16	23
27	s	nw	nw	304	34	37
28	se	nw	ne	223	20	24
29	e	nw	w	194	12	17
30	s	sw	se	326	22	26
Sum				7913		
Daily mean				263.7		
Hourly mean				10.9		

OCTOBER

Date	DIRECTION FROM			Daily distance in miles	Greatest number miles in one hour of day	Maximum velocity in miles per hour
	7 a. m.	Noon	7 p. m.			
1	s	s	sw	455	45	50
2	s	w	e	258	10	24
3	e	nw	ne	236	20	24
4	s	w	n	167	21	26
5	s	nw	nw	131	9	13
6	se	nw	nw	198	10	25
7	n	ne	ne	315	15	20
8	s	w	sw	270	23	28
9	nw	n	nw	342	29	35
10	se	s	se	240	23	25
11	se	sw	sw	663	40	44
12	nw	sw	w	382	31	36
13	n	ne	se	221	17	24
14	e	se	e	580	40	48
15	nw	n	nw	328	22	30
16	w	w	sw	404	29	35
17	w	sw	nw	432	20	24
18	se	sw	w	406	27	36
19	sw	sw	s	358	20	25
20	sw	se	e	472	35	40
21	e	s	se	237	23	27
22	s	sw	s	339	24	30
23	se	w	w	326	26	32
24	ne	n	ne	256	18	25
25	ne	e	e	125	12	15
26	s	sw	w	250	14	21
27	se	w	e	167	15	20
28	se	sw	e	174	11	16
29	s	sw	sw	200	16	20
30	s	w	ne	229	14	16
31	ne	ne	ne	431	30	36
Sum				9601		
Daily mean				309.7		
Hourly mean				12.9		

TABLE V (Concluded).—*Wind Record.*

NOVEMBER

Date	DIRECTION FROM			Daily distance in miles	Greatest number miles in one hour of day	Maximum velocity in miles per hour
	7 a. m.	Noon	7 p. m.			
1	e	w	se	133	14	18
2	s	w	e	184	12	15
3	e	nw	se	136	10	12
4	e	w	s	206	14	20
5	se	sw	nw	310	21	25
6	e	nw	w	208	18	23
7	se	nw	w	209	20	24
8	s	sw	s	203	21	25
9	se	sw	sw	326	29	35
10	s	sw	ne	187	12	20
11	sw	w	s	233	20	26
12	e	w	se	219	22	30
13	n	w	se	200	15	21
14	se	w	se	285	23	29
15	se	se	sw	274	31	38
16	w	w	sw	544	28	36
17	sw	w	n	252	16	19
18	s	nw	e	223	18	23
19	e	se	n	227	12	16
20	n	n	ne	177	13	18
21	se	nw	e	290	23	27
22	ne	n	n	158	17	24
23	n	nw	nw	122	10	13
24	se	nw	n	117	11	12
25	s	nw	n	126	16	21
26	se	se	e	124	10	12
27	s	w	sw	258	15	19
28	w	w	w	467	32	36
29	se	w	w	501	43	56
30	nw	w	sw	646	33	38
Sum				7245		
Daily mean				241.5		
Hourly mean				10		

DECEMBER

Date	DIRECTION FROM			Daily distance in miles	Greatest number miles in one hour of day	Maximum velocity in miles per hour
	7 a. m.	Noon	7 p. m.			
1	w	w	w	576	34	39
2	nw	nw	nw	553	27	35
3	se	nw	s	275	23	27
4	n	n	e	198	8	12
5	se	sw	s	212	17	23
6	w	nw	s	416	23	29
7	se	w	s	294	21	25
8	w	sw	n	281	25	31
9	ne	n	nw	395	25	31
10	se	se	sw	147	15	20
11	s	sw	w	323	21	27
12	w	w	sw	419	34	37
13	se	w	e	97	8	12
14	w	w	se	282	17	21
15	sw	sw	se	270	24	30
16	sw	nw	n	350	20	25
17	ne	n	n	193	14	20
18	n	s	s	164	18	23
19	se	s	se	222	16	19
20	se	s	se	139	15	20
21	se	nw	se	146	9	13
22	e	se	se	202	11	14
23	s	s	se	200	13	18
24	sw	sw	sw	367	30	33
25	sw	s	s	282	29	35
26	s	sw	w	425	33	37
27	s	s	ne	244	21	25
28	sw	s	se	192	13	20
29	s	s	s	220	12	15
30	s	s	s	310	20	24
31	nw	n	w	466	25	32
Sum				8860		
Daily mean				285.8		
Hourly mean				11.9		

TABLE VI.—*Precipitation and Evaporation (in inches), Laramie, Wyo.*

MONTH	1891		1892		1893		1894		1895		1896		1897		1898		1899	
	Rainfall	Evaporation	Rainfall	Evaporation	Rainfall	Evaporation	Rainfall	Evaporation	Rainfall	Evaporation	Rainfall	Evaporation	Rainfall	Evaporation	Rainfall	Evaporation	Rainfall	Evaporation
January	.70	. . .	.01	. . .	T	. . .	.03	. . .	.08	. . .	.44	. . .	.39	. . .	.05	. . .	.95	. . .
February	.375	. . .	.36	. . .	.11	. . .	.10	. . .	.14	. . .	.17	. . .	.16	. . .	.01	. . .	1.13	. . .
March	1.50	. . .	.52	. . .	.29	†	.29	. . .	.43	. . .	.59	. . .	3.97	. . .	.40	. . .	1.11	. . .
April	.25	. . .	.19	*	.32	*e*.562	1.51	*f*.906	.87	*g*2.530	3.53	. . .	.55	*i* 1.80	1.26	*k*3.44	1.75	*m*.87
May	2.92	. . .	1.16	*c*1.59	.33	4.801	.42	6.060	2.09	7.334	.48	. . .	1.85	7.43	1.88	4.60	.37	4.42
June	.91	. . .	3.97	8.23	.54	7.884	.64	7.492	2.12	6.236	.72	7.79	.72	7.73	.90	‡10.33	1.11	3.90
July	1.20	*a*4.424	2.22	9.19	.34	9.352	1.41	6.690	2.71	7.294	1.66	8.34	1.29	7.00	.65	8.37	2.01	2.91
August	1.76	8.590	.14	8.27	1.08	6.586	1.26	6.276	1.17	6.066	.89	6.09	1.11	7.33	1.16	6.93	1.43	3.14
September	1.80	5.040	T	6.10	.39	6.016	1.60	6.436	.18	4.944	1.16	4.84	.32	4.84	T	5.68	.17	4.12
October	.30	3.720	3.96	*d*1.50	.28	2.886	.09	3.306	.74	2.616	.18	*h*2.00	.55	*j* 4.38	.48	*l* 2.05	1.13	*n*1.22
November	1.095	*b*.926	T	. . .	.06	. . .	.05	. . .	.32	. . .	.09	. . .	.33	. . .	.61	. . .	.07	. . .
December	1.11	. . .	.20	. . .	.10	. . .	.23	. . .	.33	. . .	. . .	. . .	.75	. . .	.23	. . .	.61	. . .
Total	13.92	22.7	12.73	34.88	3.84	38.087	7.63	37.166	11.15	37.020	10.75	29.06	11.99	40.51	7.63	41.40	11.84	20.58

a 22d to 31st *b* 1st to 11th *c* 24th to 31st *d* 1st to 10th *e* 24th to 30th *f* 26th to 30th *g* 17th to 30th
h 1st to 22d *i* 24th to 30th *j* 1st to 26th *k* 15th to 30th *l* 1st to 15th *m* 22d to 30th *n* 1st to 15th

*Evaporation between November 11 and May 24 was 9.60 inches—liable to considerable error.

†From October 1, 1892, to October 1, 1893, evaporation was, apparently, 46.305 inches.

‡An exceptionally dry and windy month.

UNIVERSITY OF WYOMING.

Agricultural College Department.

WYOMING EXPERIMENT STATION,

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Some Experiments With Subsoiling.

BY B. C. BUFFUM AND W. H. FAIRFIELD.

Bulletins will be sent free upon request. Address: Director Experiment Station, Laramie, Wyo.

Wyoming Agricultural Experiment Station.

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Some Experiments With Subsoiling.

BY B. C. BUFFUM AND W. H. FAIRFIELD.

The natural requisites for farming are soil, water, air, heat and sunshine. With one exception these natural blessings are sufficiently abundant in the arid west. That exception is water. The greatest question in our agriculture is how to make the most of our limited supply of this life-giving element. Making use of our water supply would be a comparatively simple matter if all the moisture which might be brought to the soil could be held there until plants could make use of it. But water is never still. In seeking its common level, the sea, it runs off the surface of the land, or seeps through the upper layers, escaping from below and that which is retained for a time by the soil is being continually dissipated into the air as invisible vapor. In our dry climate the evaporation is so great that five or ten times as much water as comes to the earth in a year by rain would be lost by this process alone. Any practical plan then of saving as much moisture as possible for the use of crops is of great importance and value.

Tillage consists of stirring the soil and is as old as agriculture. Its effect is somewhat complex. It breaks up the soil admitting air, without which plants can not grow. It loosens the soil so it becomes suitable for planting the seed, as well as for the development of plant roots and for the absorption of water, brought to it by rain or irrigation. It disintegrates the soil particles continually unlocking and making available to the plant new stores of plant food. It destroys weeds. Breaking up the surface forms a blanket which prevents the rapid loss of water by evaporation. Is it enough that we shall cultivate the surface of the earth, or shall we find it profitable to extend tillage deeper into the hitherto undisturbed subsoil?

Subsoiling is stirring the earth below the region of the plow. For convenience we speak of the first eight inches of soil which may be turned over in plowing as the surface soil and all below this as the subsoil. Plowing turns the surface soil bottom side up. Subsoiling does not change the position of that part of the soil, but it breaks up and stirs the ground below the ordinary depth of plowing. This may be effected by a spur or prong attached to the plow which breaks up the soil at the bottom of the furrow, or it may be done with a separate implement to be drawn along through the soil beneath the bottom of the furrow after the plow, to stir the ground to greater depths than can be done with a small attachment to the ordinary plow. This implement is called the subsoil plow and usually consists of a mole or a more or less flat piece of iron pointed at one end and attached to the beam by a strong flat vertical blade. When drawn through the soil in the bottom of the furrow left by the plow this implement can be made to break up and stir the subsoil to a depth of from one to two or more feet.

The advantages claimed for subsoiling are that it makes more room for root development, and enables the plant to extract food and moisture from a greater area, and that by loosening up more of the soil its capacity for absorbing and retaining moisture is increased. By the absorption of greater amounts of moisture in winter and spring it is supposed that subsoiling provides against summer drouth. It is reasonable to suppose that this is what would happen and the many favorable reports on subsoiling from humid and semi-arid regions indicate that loosening the lower layers of soil is a valuable way of conserving moisture for those regions. Before discussing the effects of subsoiling in Wyoming the differences between a truly arid region and one which is only semi-arid should be briefly pointed out. Places where the annual rainfall is less than fifteen inches are generally called arid. The air is dry; the evaporation is great; the rainfall is not sufficient to mature cultivated crops. In the semi-arid region the rainfall is more than fifteen inches and may be enough to mature profitable crops if the moisture can be stored up in the soil and saved until the crop can make use of it. In Wyoming the conditions are truly arid unless it be in the extreme northeastern portion of the state. There is little precipitation during the fall and winter, so very little moisture escapes by running directly off the surface of the land. If, then, subsoiling is not necessary to increase the holding capacity of the soil, and absorb water during time of extra supply, will it save more of the water which may be applied artificially during the growing season and will this and other advantages make it profitable to go to the extra expense of such tillage in our state?

To solve this question we have been experimenting with subsoiling for three years and this bulletin is published to report the results obtained. The experiment was conducted in the same manner on the several experiment farms in the state. Unfortunately the records of the Lander farm were lost in transit, and the publication of this bulletin has been long delayed with the hope they might be found. The soil of the Lander and Sundance farms is almost identical, the altitude of the two places is not far different and while the experiment in subsoiling was only carried out one season at Sundance, a comparison of the results obtained would be highly interesting. The climate of Sundance is semi-arid or sub-humid, crops being raised without irrigation, while that of Lander is arid and no crops are raised without irrigation. A comparison of the results at these places would give more trustworthy evidence of the difference in value of subsoiling under such conditions of climate and farm practice.

The experiment was begun in the spring of 1896 and carried out that year at Laramie, Lander, Sheridan, Sundance and Wheatland. In 1897 the cropping was repeated on the same land at Laramie, Lander and Sheridan, and in 1898, at Laramie only.

PLAN OF THE EXPERIMENT.

Following is an outline of the instructions for subsoiling which, with slight modifications for each locality, were furnished the farm superintendents in the spring of 1896—

This experiment is to be carried on alike on each of the farms. Select a suitable acre plat. Plow the land over the whole plat the same and let all other operations such as harrowing, etc., be the same for all parts of the plat. Subsoil thoroughly one-half of the plat. Mark carefully and permanently the line where the subsoiling stops.

Divide the plat into four equal parts so one-half of each fourth is on the subsoiled portion and one-half on the part merely plowed.

Upon the first fourth acre plant oats.

Upon the second fourth acre plant potatoes.

Upon the third fourth acre plant wheat.

Divide the last fourth into two parts and plant beets on the one and corn on the other.

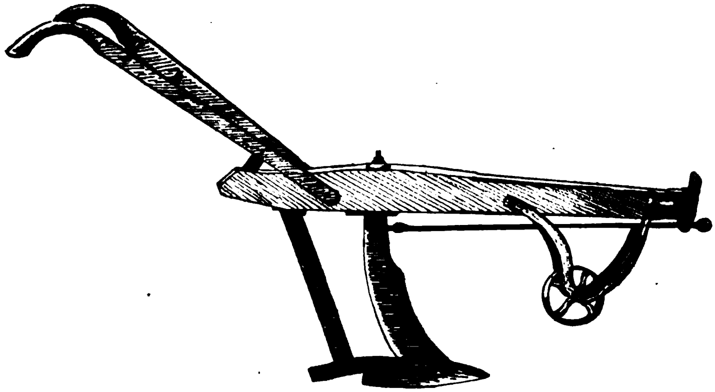
Treat the crops on the plowed and subsoiled land the same throughout the season. Keep careful notes of any variations on the two parts of each plat.

When you harvest each crop cut out a strip six feet wide along the line on which the subsoiling stops, casting out the crop from a strip three feet wide on each side of this line, which part is to be taken no account of in figuring up the yields on subsoiled land or land not subsoiled. This is important as the effects on the ground treated or untreated will reach across the line some distance.

Measure the area in square feet occupied by each crop to be used in figuring up the yields. In the case of rowed crops, allow for the number of rows at their distance apart and take the length of row on treated and untreated land.

This experiment will be repeated upon the same ground for a number of years to determine the effect of subsoiling on soil and crops—.

In 1898 some additional land was subsoiled and on one plat of oats covering one-half acre an accurate measurement was made of the irrigation water used. In 1897, the next year after the land was subsoiled for this experiment, the Physicist made a study of the moisture content of different soils which was published in Bulletin No. 35 of this Station, a resume of which is used in this report.



Results of the Experiments.

Plants of different kinds act very differently when grown on subsoiled land. The effect on a crop of loosening the soil to a depth greater than by ordinary plowing is also very different on different soils and under varying climatic conditions. Our experiments were carried out in widely separated parts of Wyoming and with the more important crops raised in each section. Again there are often accidental variations which throw doubt on the value of an experiment and where possible the work has been repeated more than one season. The conclusions reached have been carefully drawn and we believe the results of these experiments are worthy of consideration by our farmers.

The soil on the station farm at Laramie contains considerable gypsum and lime carbonate, is quite sticky when wet and becomes firmly compacted below the plow. The land selected for this experiment had been cultivated for a number of years. It was plowed about eight inches deep and one-half the plat was subsoiled to a depth of fourteen to sixteen inches in April, 1896. The ground was so hard that four horses were required to pull the subsoil plow and if larger areas were to be treated six horses would be necessary. The land was not again subsoiled but the difference in the yield of crops produced was observed for three seasons. This shows the lasting effects of subsoiling and the return which may be expected from one such treatment, and throws light on the absorption and retension of water through the entire year. The second year there was a slight difference in the depth of the plowing on the two portions of the plat. Where the land had been subsoiled the plow sunk one to three inches deeper than on the plowed portion.

On the other station farms in the state the plowing and subsoiling was done in the same manner as at Laramie. At Sheridan the soil is clay underlaid with true hardpan. It is not known to what extent this hardpan was broken up by the subsoil plow. At Wheatland the soil conditions are much the same as those at Laramie. At Sundance the soil is deep, contains gypsum and much of the subsoil consists of red shale which is not tenaceous but comparatively easy to work.

The average rainfall is nearly ten inches at Laramie; about the same at Wheatland, nearly fourteen inches at Sheridan and twenty inches at Sundance. At Laramie and Wheatland from fifty to sixty percent of the total annual precipitation falls in the growing months of May, June, July and August. The greater amount of precipitation at Sundance and the fact that the land was not irrigated undoubtedly accounts for some of the difference noted in the effects of subsoiling between the Sundance and other farms.

Subsoiling for Grain Crops.

Table I. gives the effects of subsoiling on the yields of wheat. Though the difference was not great, the yield from the subsoiled land was less than that from the land only plowed, at Laramie, the year the subsoiling was done. The second and third years there was a slight increase in yield from the subsoiled land. The increase in the yield of straw is greater in proportion than that of grain. This condition would be expected as the increased feeding area of the roots and other conditions favoring rank growth would produce more straw and less grain where the growing season is short. The reason for this is indicated in Wyoming Station Bulletin No. 37 on the "Stooling of Grains." It is a general law that under adverse conditions plants strive to mature seed in order to reproduce themselves. Under these conditions then, grain will mature earlier and produce more seed in proportion to the rest of the plant than where everything is favorable to long continued growth.

TABLE I.—*Subsoiling for Wheat.*

Yields in Pounds per Acre.

		LARAMIE.		SHERIDAN.	WHEAT-LAND.	SUNDANCE.	
		Straw and Grain	Grain	Grain.	Grain.	Straw and Grain.	Grain.
First Year.	Subsoiled	2627	943	3000	1726	3920	1440
	Plowed	2863	997	2550	1614	3441	1160
	Gain			450	112	480	280
	Loss	236	54				
Second Year.	Subsoiled	2174	901	2700			
	Plowed	1894	876	1950			
	Gain	280	25	750			
Third Year.	Subsoiled	2170	908				
	Plowed	2127	833				
	Gain	43	85				

The increase in yield of wheat at Laramie the second and third years on the land which had been subsoiled is but little more than enough to balance the decrease the first season. At Sheridan there was an increase in yield the first year of seven and one-half bushels and the second year of twelve and one-half bushels on subsoiled land. At Wheatland and Sundance the increase on subsoiled land was small but was over twice as much at Sundance as at Wheatland.

The results with oats are given in Table II. The lengthening of the season for oats by subsoiling was more marked than with wheat. At Sundance the oats on the subsoiled portion of the plat seemed to be making better growth during the first part of the season but, when harvested, Superintendent Hoyt reported a smaller yield than was obtained from the land treated in the ordinary way. At Laramie the oats were later in reaching maturity on the subsoiled land. It may be stated that late varieties of nearly all crops, if not interfered with by frost, produce heavier yields than those which require only a short season in which to mature. Lengthening the growing season for the same variety would be expected to increase the yield, but at the high altitude of the land over a large part of Wyoming the time between late and early frosts is comparatively short and earliness in ripening is a most important factor. There was a slight increase in yield of oats the first two years, but the third season the decrease in crop was almost enough to balance the gains of the first two seasons, though whether or not the effect the third season was due to subsoiling may be questioned.

At Sheridan there was a loss of seventy pounds more of oats the first year than was gained the second year by subsoiling. At Wheatland there was a small increase on the subsoiled land, but the variation was small, probably not more than would be obtained on any two plats, though treated exactly alike. To all appearances the yields of oats were not materially influenced at any place by subsoiling the land.

TABLE II.—*Subsoiling for Oats.*

Yield in Pounds per Acre.

		LARAMIE.		SHERIDAN.	WHEATLAND.	SUNDANCE.	
		Straw.	Grain.	Grain.	Grain.	Straw.	Grain.
First Year	Subsoiled	4390	1520	3070	1898	1960	512
	Plowed	3898	1345	3360	1614	2224	648
	Gain	492	175	—	184	—	—
	Loss			290		356	136
Second Year.	Subsoiled	3555	1345	2700			
	Plowed	3378	1194	2480			
	Gain	177	151	220			
Third Year.	Subsoiled	3645	1302				
	Plowed	4445	1526				
	Gain	—	—				
	Loss	800	224				

Because of the high altitude with the accompanying short seasons and cold nights, corn is not grown at Laramie, so barley was planted on one portion of the subsoiled plat at this place and corn was grown at Sheridan, Wheatland and Sundance instead of barley. The results with barley and corn are given in Table III. It is doubtful if any effect on the yields of barley one way or another can be traced to the subsoiling. The first year there was less straw and more grain on the subsoiled land. The second year this was reversed, there being more straw and less grain where subsoiled, and the third year there was aproximately no difference in the production of straw, but there was quite a decrease in the yield of grain.

Subsoiling for corn did not pay at the sub-stations except at Sundance where a good increase in yield was obtained. At Sheridan there was quite a large decrease in yield of corn the first season, and no difference the second year. Superintendent Lewis reported that the corn did not mature as well on the subsoiled land. The first year the estimated yield on the subsoiled part of the plat was thirty bushels per acre, and on the land not subsoiled thirty-five bushels per acre. Ten per cent. of the corn on the land merely plowed ripened thoroughly, while all the grain from the subsoiled portion of the plat was soft and immature. The second season fifty bushels of mature and thirty bushels of soft grain per acre were harvested from each portion of the plat. To compare with others in the table, these yields have been reduced to pounds by using the weight of seventy pounds per bushel for corn in the ear.

At Wheatland during the season of 1896, the supply of water for irrigation was somewhat limited, and if the crops suffered for water, as they probably did to some extent, those on the subsoiled land would be expected to have the advantage. Mr. M. R. Johnson, the superintendent, states that all the crops made a better growth on the subsoiled land, that they seemed to withstand drouth better, and that the quality as well as the quantity of the product, indicated beneficial effects from subsoiling. The corn gave an increased yield of 363 pounds per acre on the subsoiled land.

TABLE III.—*Subsoiling for Barley and Corn.*

Yield in Pounds per Acre.

		LARAMIE.		SHERIDAN.	WHEATLAND.	SUNDANCE.
		Barley.		Corn.	Corn.	Corn.
		Straw.	Grain.	Grain.	Grain.	Grain.
First Year.	Subsoiled	2944	1325	2100	3590	3008
	Plowed	2989	1292	2450	2227	2416
	Gain	—	33	—	363	592
	Loss	45	—	350	—	—
Second Year.	Subsoiled	4602	1479	3500		
	Plowed	4123	1668	3500		
	Gain	479	—	—		
	Loss	—	189	—		
Third Year.	Subsoiled	2169	527			
	Plowed	2175	752			
	Gain	—	—			
	Loss	6	225			

Subsoiling for Root Crops.

The fact that deep soils are favorable for the growth of roots is recognized everywhere, and as would be expected subsoiling produced more marked effects on the yields of root crops than it did on grains. In Table IV., reporting the results with root crops, it will be seen that in every trial there was increased yield from the subsoiled land, and in some instances there are important gains. The lasting effect of subsoiling is well brought out in this table. All the tables show that, at Sherman, where the experiment was carried out two years, and at Laramie where results were obtained three seasons, the beneficial effect of subsoiling is greater the second year than it is the season the subsoiling is done. This indicates that it would be advisable to subsoil in the fall rather than in the spring. The third year the soil has probably become compacted again so the effect is much less than it is the first two seasons.

TABLE IV.—*Subsoiling for Root Crops.*

Yield in Pounds per Acre.

		LARAMIE.			SHERIDAN.		WHEATLAND.		SUNDANCE.	
		Potatoes	Beets.	Turnips.	Potatoes.	Beets	Potatoes.	Beets.	Potatoes.	Beets.
First Year.	Subsoiled			8695	12858	13860	2425	8302	8224	17161
	Plowed			8380	10620	12600	2151	8009	6960	14841
	Gain			315	2238	1260	274	293	1264	2320
Second Year.	Subsoiled	3672	12893			28700				
	Plowed	2620	11643			24795				
	Gain	1052	1250			3905				
Third Year.	Subsoiled	6940	5450							
	Plowed	6865	4522							
	Gain	75	928							

POTATOES—At Laramie the potatoes planted the first year failed to grow because the soil was too dry. The second and third years the stand was poor and small yields were obtained, but there was a good increase of crop on the subsoiled land. In Table IV. only the yields of potatoes which were of sufficient size for market are reported. The proportion of large and small tubers on the two kinds of ground and the increase in size on the subsoiled land is of interest. Table V. gives the yields of large and small potatoes, the percent marketable and the weight of the largest twelve tubers from each portion of the plat at Laramie in 1897 and 1898. The difference in yield in 1898 is small and there was practically no difference in the size of the potatoes, indicating that little effect on this crop was produced by the lower soil having been loosened up three years before. The second season after subsoiling, however, there was not only a large increase in the yield, but in the size of the tubers as well.

TABLE V.—*Effect of Subsoiling on Size of Potatoes.*

at Laramie, Wyo.

	1897.				1898.			
	Yield.		Percent. Market-able	Weight of largest twelve.	Yield		Percent. market-able.	Weight of largest twelve
	Large.	Small.			Large.	Small.		
Subsoiled	3672	1552	70.3	5.1	6960	2417	74.2	4.6
Plowed	2620	1660	61.2	4.5	6885	2212	75.5	4.6
Gain	1052	892	9.1	0.6	75	205		

At Wheatland the subsoiling produced little effect on potatoes. The increase in yield of marketable potatoes was only 274 pounds. Of the entire crop 62.8 percent were marketable on subsoiled land, and on the land not subsoiled the marketable tubers were 63.6 per cent of the whole crop. At Sheridan and Sundance the small potatoes were not reported, but at Sheridan the largest 12 tubers from subsoiled land weighed six and one-half pounds and from plowed land six pounds.

SUGAR BEETS—Subsoiling gave satisfactory increase in yields of sugar beets at every place except Sheridan. At

Laramie the increase in size of the beets is worthy of special mention. Not only were the largest twelve very different, from the two plats, but the average size of the roots was much larger on the deep soil. In 1897 the largest twelve roots from the subsoiled plat weighed nineteen pounds and from the plat not subsoiled twelve roots weighed eleven pounds. In 1898 the difference was less.

Twelve of the largest beets from the subsoiled plat weighed in the aggregate seven and one-half pounds and from the plowed land six and one-half pounds. Analysis of the beets showed slightly better results from the land not subsoiled. Beets from subsoiled land contained 19.7 percent sugar and had a purity of 88.2, while those from the adjoining plowed land contained 20.3 percent sugar and had a purity of 92.7.* The analyses were made from the crop of 1897, the second year after subsoiling.

SUBSOILING, IRRIGATION AND SOIL MOISTURE.

The subsoil plats were small, and as it was necessary to treat the crops alike on both parts of the plat, it was impossible to measure the amount of water used on each portion. An experiment was carried out with different amounts of water on the potatoes growing on the subsoiled land in 1897. Measurements were made of the total amount of water used on the plat, one half of which was subsoiled and also on another subsoiled plat, and we are able to compare these measurements with the amount of water used on other fields. During the season of 1897 the Physicist made a series of moisture determinations on the different soils and published the results in Bulletin No. 35, a resume of which is shown in the accompanying diagram. These observations enable us to draw some conclusions in relation to the soil moisture and the use of irrigation water on such deeply tilled soils at Laramie.

In 1896 the barley, oats and wheat, were irrigated twice, on the acre of land one-half of which was subsoiled. At the first irrigation on July 2, enough water was applied to cover the land 11.4 inches deep and at the second irrigation enough water was applied to cover the land 6.12 inches deep, or a total depth for these crops of 17.52 inches. The precipitation for the year was 10.75 inches of which 4.75 inches fell during the months of May, June, July and August. This gave a total of 22.27 inches for the growing season or 28.22 inches of water for the year. The same year wheat and oats on other fields received enough water by irrigation to cover the land to a depth of 14.88 inches, and barley received 14.52 inches of water, showing that enough more water was applied to the acre, one-half of which was subsoiled, to cover the whole plat three inches deep. If this was due to the effect of subsoiling it means a requirement of six inches more water on the subsoiled land. Unfortunately the record of measurements of water on the subsoiled plat was broken, so it cannot be reported for 1897, but in 1898, trustworthy measurements were secured. The wheat. oats and barley were irrigated twice. On June 24, enough water was applied to cover the land 11.52 inches deep, and July 13 enough water to cover it 9.12 inches deep or a total of 20.64 inches. Including the rainfall, the land received enough water during the growing season to cover it to a depth of 25.22 inches, and in the year 28.26 inches. It is not possible to draw conclusions in regard to the effect of the subsoiling on this plat in 1898, as other crops of the same kind received varying quantities of water, some more and some less than this amount.

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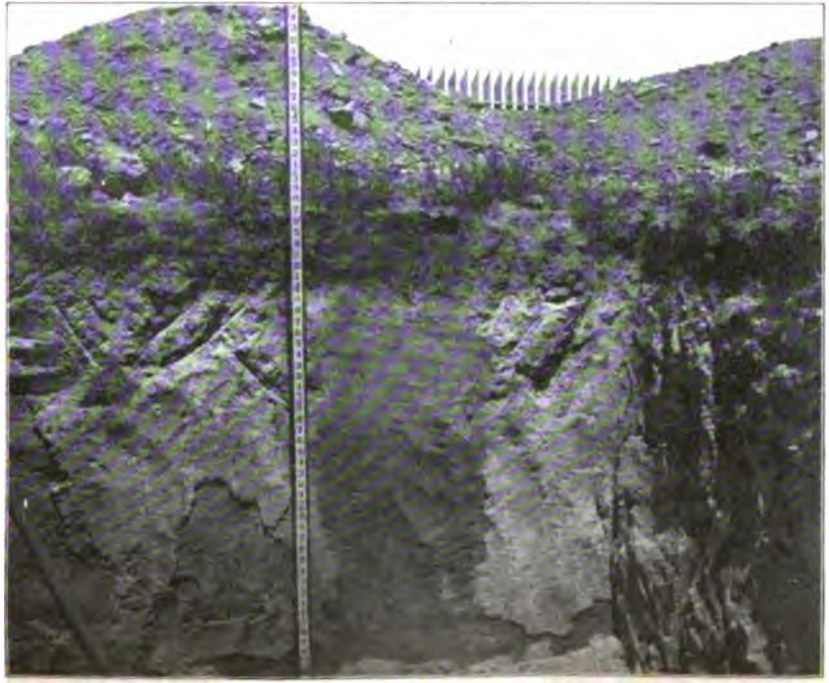
*See Wyoming Station Bulletin No. 36, Page 197.

On another plat, however, which was subsoiled in the spring of 1898 and planted to oats, the amount of water used in irrigation was very large. The land was irrigated twice. At the first irrigation on June 27, enough water was used to cover the land 30.84 inches deep, and all of it was absorbed by the soil. At the second irrigation, July 11, enough was used to cover the land 13.44 inches deep.

UNIV.
OF



FIVE FEET OF SOIL, LARAMIE FARM.
One Year after Subsoiling.

making a total for the season of 44.48 inches, or 3.69 feet. Including the rainfall, this gave a depth of water brought to this land in the year of 51.91 inches or for the growing season of 48.47 inches. The amounts of water used on other plats of grain in 1898, was 1.90 feet on one field of oats, 2.58 feet for oats on sod, 1.55 feet for oats and cultivated grain, 2.70 feet for one plat of barley, 1.74 feet for one plat of wheat and oats, and 3.63 feet for one field of wheat, which was irrigated three times and given an unusual amount of water.

The illustration of five feet of soil on the Experiment Station is made from a photograph taken one year after the subsoiling was done. The upper eight inches of dark soil is the portion turned over each year by the plow. The next six or eight inches of subsoil shows the effect of having been loosened by the subsoil plow, leaving it porus. On the native plains the soil below the first one or two feet may not have been wet for ages, as the natural rainfall is not sufficient to wet more than the first few inches of surface, and there is practically no difference in composition between the surface and subsoil. Breaking up the layer which is compacted by the plow in the bottom of the furrow gives the water a new reservoir below the plowed land and affords a means of escape by seepage, which would account for the large amounts necessary to soak it up when irrigated and perhaps also for easy dissemmination and loss of the moisture afterwards.

In 1898 the potatoes on the plat, one-half of which was subsoiled, were divided into two parts. One part was irrigated twice, using only a small amount of water each time and the other part was irrigated three times. Those irrigated twice received enough water to cover the land 2.04 inches deep on July 28, and 1.56 inches deep on August 4. The ones irrigated three times received the first irrigation on July 7, when enough was applied to cover the land 10.20 inches deep. At the other two irrigations they were given the same amounts as the potatoes which were irrigated but twice. The results are given in Table VI., which shows the amount of water applied and the yields on land subsoiled and not subsoiled.

TABLE VI.—*Potatoes with Two and Three Irrigations on Subsoiled Land.*

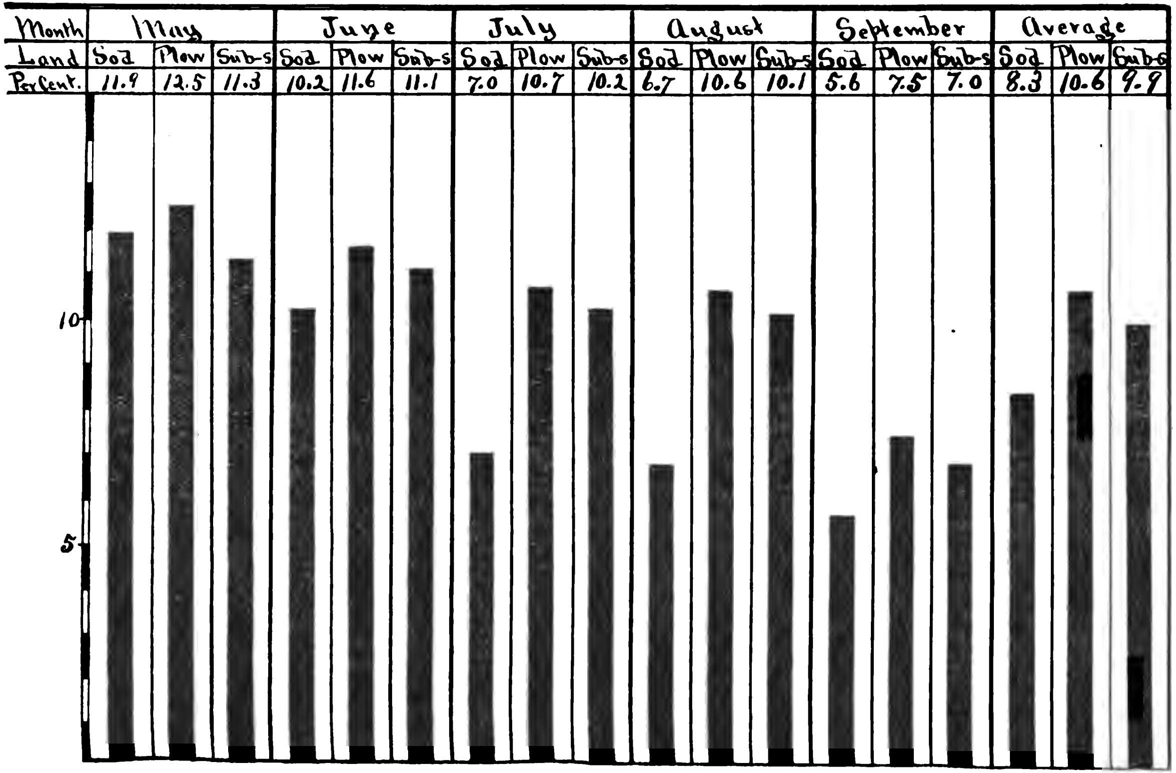
Laramie, Wyo., 1898.

	Total amount of water applied. Inches.	Yield on land plowed. Pounds.	Yield on subsoiled land. Pounds.	Average yield. Pounds.	Weight of largest twelve plowed. Pounds.	Weight of largest twelve Subsoiled. Pounds.
Irrigated twice	3.6	4972	5290	5131	3.6	3.9
Irrigated three times.	13.8	8759	8591	8675	5.6	5.3
Increase	10.2	3787	3301	3544	2.0	1.4

This shows an increase due to the increased amount of water applied, of over seventy-six percent on plowed land, and sixty-two percent on subsoiled land, the average increase being about sixty-nine per cent. The fact that increased water applied in irrigation did not increase the crop as much on subsoiled land as on the land which was plowed is in favor of the subsoiled land as it indicates that the crop actually needed less water to produce the same yield. This may be true, as the variation is small and may be accidental, and it is possible and probable that more water was actually absorbed by the subsoiled portion when irrigated. It is unfortunate that we are not able to make a like comparison the first and second seasons after subsoiling.

If moisture comes to the soil during any part of the year, the friends of subsoiling claim that it is retained and made more available to the crop. The study of the moisture in the soil of the different plats at Laramie in 1897, which was made by the Department of Physics, does not seem to bear out such statement. The accompanying chart illustrates the difference in moisture content of the soils on sod land, on land which was plowed in the usual way and on the subsoiled land. The determinations of moisture were made daily and these have been averaged for each month. The samples were taken to the depth of one foot by driving tubes about one inch in diameter into the soil. On the loose ground some of the soil might be driven down in front of the tube instead of entering it, but the samples were carefully taken and no effect of the kind was noted. The vertical black lines in the chart represent the average percent of moisture in the soil which is also expressed in figures at the top of each column. The last three columns at the right represent the average percent of moisture for the summer. The lowest moisture content observed was 2.52 percent in sod land, September 24. The highest percent observed was 22.25 on the land plowed but not subsoiled and immediately after irrigating it. The amount dropped to 19.7 percent the second day, and to 15.76 percent the third day. On the subsoiled part of the plat after irrigating the percent was 21.15 the first day, 21.76 the second day, decreasing to 16.23 the third day after applying the water. There is little difference in the average moisture of the surface soil on the plowed land and that subsoiled, but what difference there is shows less moisture on the subsoiled land throughout the summer. These facts indicate that more water was needed at Laramie to irrigate subsoiled land and less of it was retained by the surface soil for the use of the plants growing thereon. It is possible there was more water in the soil below the depth of these samples on the subsoiled plat, but the difference was not great enough to produce marked effects on the crops. At Sheridan the Superintendent states that more water was required at the first irrigation and less at the second on the subsoiled land. At Wheatland the crops seemed to be less affected by drouth where subsoiled. This may have been due to an excess of water absorbed by the subsoiled land when it was irrigated.

Soil Moisture, 1897.



Month	May			June			July			August			September			Average		
Land	Sod	Plow	Sub-s	Sod	Plow	Sub-s	Sod	Plow	Sub-s	Sod	Plow	Sub-s	Sod	Plow	Sub-s	Sod	Plow	Sub-s
Percent.	11.9	12.5	11.3	10.2	11.6	11.1	7.0	10.7	10.2	6.7	10.6	10.1	5.6	7.5	7.0	8.3	10.6	9.9

DOES SUBSOILING PAY ?

The test of the advisability of any operation on the farm lies in the final result measured in dollars and cents. Subsoiling is an expensive operation which more than doubles the ordinary cost of preparing the land for the crop by plowing. The cost of subsoiling will vary with the condition of the soil and the price of labor. The cheapest it could be done on large areas, and thoroughly done as in these experiments, would be at a cost of not less than three dollars per acre. Where we broke up the subsoil to a depth of fourteen to sixteen inches, on small plats the expense was five or six dollars per acre. Unless it increases the yield, improves the quality and therefore the value of the crop, or reduces the expense of producing it, or requires less water so the same supply will irrigate more land, the practice of subsoiling cannot be recommended as one to be adopted on the farm.

Referring to Table I. in which the yields of wheat on subsoiled land and on land prepared in the ordinary way are compared, it is evident that the accumulated increase for three seasons at Laramie would not pay the expense of one subsoiling. At Sheridan the increase of 450 pounds of wheat per acre the first year and 750 pounds the second due to subsoiling would give a total value of twelve dollars per acre more from the subsoiled land. If the subsoiling cost four dollars per acre more than the ordinary expense of plowing, the margin of profit is large enough. Even though we allow for a considerable increase in yields the second year at Wheatland and Sundance, subsoiling would not pay for wheat in these localities.

The results with oats as given in Table II. do not show any marked or uniform improvement in the crop. So far as our experiments may be relied upon as showing the true effects of subsoiling in this state, the indications are that it will not pay to so prepare the soil for oats. The same statement may be made for barley and corn unless it be at Sundance, where the increase the first year and the probability that there would also be a like increase in the crop the second year, indicate that subsoiling for corn might pay in that region.

Subsoiling for root crops did not give a return the first year at Wheatland, large enough to pay the cost, though the quality of the crop was improved and the increase the second season might leave a profit. At Laramie the increase in the potato crop the second year (see Table IV, page 11), would be worth $10.50 to $13.00 at the local market price. On the Sheridan farm the increased yield of potatoes the first year was worth from $11 to $20, and at Sundance from $6 to $12, depending on the market price. The value of sugar beets for stock food would make the increased yields from subsoiled land at Laramie, Sheridan and Sundance profitable. As a rule we believe that subsoiling for root crops will bring a profitable return.

Whether or not subsoiling will pay depends largely on local conditions and the kind of crop. Before adopting so expensive a system of tillage the farmer should satisfy himself in regard to whether it will bring a profit on his land by making small trials. Our results can not be said to indicate that subsoiling in regions which depend on irrigation will materially assist in saving the moisture or make irrigation less necessary. It is true that subsoiling apparently mitigated the effects of drought somewhat in Wheatland, though the increase in the value of the crop was not sufficient to pay for the expense incurred. It is possible that, where water for irrigation is scarce, and other conditions are favorable, subsoiling might make the water which is available go farther in maturing a crop, though we have been unable to prove any valuable saving of moisture where the subsoil is made porus.

SUMMARY.

The expense of subsoiling to depths of sixteen or eighteen inches is from three to six dollars per acre.

Subsoiling is probably more valuable in semi-arid or humid regions than where irrigation is practiced.

The effects of once subsoiling the land may continue for three or more years and under our conditions are more apparent the second season after the subsoiling is done than they are the first.

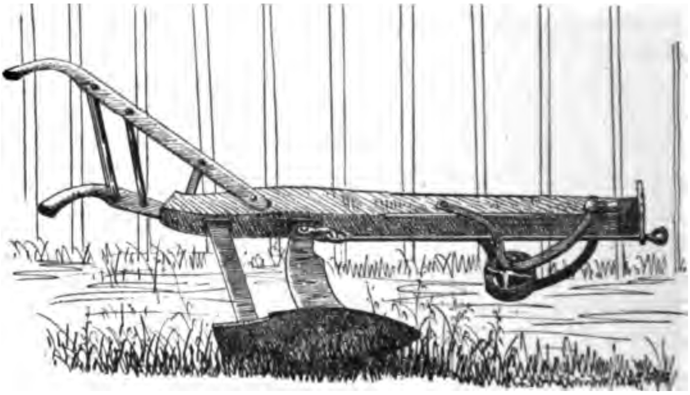
If subsoiling is to be practiced, we recommend doing it in the fall.

Subsoiling does not produce a uniform effect on the grains. Under certain conditions it may pay for wheat raised by irrigation. We have not found it profitable for oats, barley, or corn.

Grain takes longer to mature on subsoiled land. At high altitudes where the season is comparatively short it is doubtful if subsoiling for grain is advisable.

The quantity and quality of root crops are greatly improved by subsoiling the land. Subsoiling can be generally recommended in this state for potatoes.

Under our conditions subsoiling has increased the amount of water needed to irrigate the land and apparently is of little value in conserving moisture. However, if no water could be applied by irrigation during the summer, the filling with moisture in the winter or spring by rainfall or irrigation of the reservoir formed by subsoiling, would be beneficial.



UNIVERSITY OF WYOMING.
Agricultural College Department.

WYOMING EXPERIMENT STATION,

LARAMIE, WYOMING.

BULLETIN NO. 42.

DECEMBER, 1899.

Some Native Forage Plants for Alkali Soils.

BY AVEN NELSON.

Bulletins will be sent free upon request. Address: Director Experiment Station, Laramie, Wyo.

Wyoming Agricultural Experiment Station.

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SOME NATIVE FORAGE PLANTS FOR ALKALI SOILS.

AVEN NELSON.

INTRODUCTION.

There are herds and flocks on a thousand hills. These are one of the great sources of Wyoming's wealth. Though events go to prove that we must more and more become an agricultural people, yet for years to come the most remunerative agriculture must be that which finds, in the stock interests of the state, its reason for being. Thousands of horses, tens of thousands of cattle and hundreds of thousands of sheep feed within our vast domain. Can the number now supported be increased? If not, then the stock industry has reached its maximum development.

If, as has been asserted, our ranges will no longer sustain the princely herds of the days of the "cattle kings," then we are no longer occupying one of the important vantage points of the state's material greatness. That the methods followed in the management of the stock industry have materially changed admits of no question. The present status has been evolved from the early conditions in which chance and speculation played so important a part. In the early days comparatively few men were able to launch out into so deep a sea or even cared to venture on such a perilous voyage.

Herds numbering thousands of head roamed over hills and plains with no supervision except the semi-annual "round-up" for branding or for "cutting out" those animals fit for market. Furthermore, even this supervision was largely that of the hireling, the owner's eye being too often absent and his will too often easily evaded.

With no provision for caring for the stock during unfavorable winters (those with heavy snowfall or following a season of drought), whole herds were decimated many times over and the fabulous profits, which had been so alluring, were swept away.

Such experiences have wrought and are still working their own reform. The speculative features are giving place to sounder business principles and the incomes, while less alluring, are far more certain.

The product of this evolution is smaller herds in the hands of many owners, more personal and interested supervision, provision for the care and feeding of stock during inclement weather and individual control of land either by purchase or lease. Are these conditions such as would tend to diminish the stock supporting capacity of the state? It would hardly seem so. The replacing of the bonanza business by everyday prosperity must multiply even the best of the former results.

It may seem at first sight, as if the enclosing of most of the irrigable lands is simply thus to withdraw from the available pasture lands those of greatest worth. Let it be remembered, however, that irrigation increases the productiveness of these lands many fold and the increasd product is, in most cases, a direct addition to the stock-supporting capacity of the lands. Not only are the products of these irrigated lands generally made to contribute directly to the support of the stock, but it is forage secured and preserved at a time when the open range furnishes an abundance, and fed out when this resource is no longer adequate. It will be seen that instead of decreasing the amount of stock in the state, the establishment of homes and farms ought to magnify the business in proportion to the increased yield of the lands, and that the profits ought to be enlarged by reason of the decreased losses. Whether we shall actually experience these results or not depends largely upon the way in which we use our resources. A proper appreciation of the native forage plants and a discriminating, commonsense use of the pasture lands of the state must govern us.

Probably it is true that the quality and kind of native forage is not identical with that of former years, since some species are less able than others to endure the heavy pasturing, the close cropping and the constant trampling to which they are subjected. In over-irrigation and in unwise methods in the application of water we find other causes for the extinction of some species. Indiscriminate flooding drives out many valuable grasses which are replaced by rushes and sedges, less valuable but for the fact that the yield is enormously increased above that of the unirrigated tracts.

If this extinction occurs in soils in which other hardier species do not readily replace them it is a loss that must ultimately seriously affect the total forage resources unless it is met by adequate counteracting influences.

How the range may be kept up to its old value is an important question, but how it may be improved is even more so. These are questions involving so many factors that their full discussion does not fall within the province of this bulletin, but a clearer idea of what is here aimed at may be had if we roughly classify and briefly characterize certain forage areas.

FORAGE AREAS.

The distinctive regions, which are utilized for pasture, in so far as native plants are concerned, are three. These each have their season and their peculiar advantages and disadvantages.

Mountain Areas.

This term is meant to include all tracts of country lying at an elevation of 8,500 feet or more. Mountain slopes, open or partly wooded, alpine parks, and even the seemingly naked summits become luxuriantly clothed for a few weeks with nutritious grasses. The always abundant moisture ensures a certain crop and the flowing stream is never far to seek for the thirsty cattle. July and August are the safe months in these situations which are of little value later in the year. Early snows soon make the stations untenable and the hard freezes of the lengthening nights convert the succulent grasses into dead mats of little value. Little can be done looking to the improvement of these areas. Here Nature must take her own course and we can only aid her by not taxing her resources too heavily. Overstocking this kind of range, where the climatic conditions are such that mature seed is produced but sparingly under the most favorable conditions, is simply to rob ourselves of our own heritage.

We are further confronted with our responsibility to these areas on account of their relation to the water supply of the plains below. Whether it be Forest Reserve or general public domain we are interested in maintaining the forest cover for the retention of the winter snows and the conservation of the resultant moisture. Heavy pasturing can not fail to ultimately seriously affect the renewal of the forest growth.

Hill Country.

Throughout the state at intervals occur ranges of hills, either only partly wooded or wholly denuded. Broad valleys, rounded summits and undulating foot-hills give perfect drainage to these fairly well-watered areas. They may be said to include all those portions of the state lying below an altitude of 8,500 feet, except the plains discussed below. Being well drained, these areas are reasonably free from alkali. In the broader valleys may occur considerable stretches which are capable of being irrigated. In these localities it is possible to materially increase the forage product either by furnishing more favorable conditions for the native plants or by introducing more productive species. However, these hill lands, as a whole, do not lend themselves readily to any schemes for their improvement. Cultivated and irrigated with difficulty our treatment of them must be protective rather than constructive. Overstocking should be avoided and periods of rest should alternate with periods of use.

This kind of range is, perhaps, in proportion to area, the most valuable that the state affords. Whether it is more desirable as summer or as winter range depends upon its particular location in the state and upon its exposure, factors which decide its relative climatic condition. Areas eminently satisfactory as summer range may be entirely unsuited for winter use on account of heavy snow-fall while other areas which, from lack of potable waters, are quite worthless as summer range may actually fatten great herds during the winter months. The most desirable winter range is not necessarily that of scanty snow-fall but rather one whose topography is such that the snow is, in the main, blown off of the slopes and open areas, forming drifts in the draws and under the brows of the hills. These drifts insure snow and water in abundance for the stock when water in the ponds and creeks is not to be had or is unfit for use.

The Plains.

We thus designate any large comparatively level area. The value of plains as grazing lands depends upon many factors, chief among which may be mentioned the amount of rainfall and the character of the soil. These are the determining factors of the character of the vegetation and makes necessary the recognition of two kinds of areas, viz., those which are free, or nearly so, from alkali and those which are heavily charged with it.

NORMAL PLAINS: By normal plains it is intended to designate those whose soil has no unusual or detrimental amount of alkali. The soil may be of varying degrees of fertility and the forage correspondingly scanty or abundant but no problems are connected with these soils and their crops except those that are common to the arid west in general.

Whether such regions are most valuable as summer or winter range is determined by the amount and character of the forage and of the water supply for the stock. In some portions of the state the plains become buried under the early winter snows while in other parts nearly similar plains are swept bare by the winds leaving an open range throughout the year. How to secure from such lands the best possible results must be left to be considered in some future bulletin.*

ALKALI PLAINS: The soil in many portions of the state is heavily impregnated with alkali. These tracts occur in some of the more arid portions of the state as extended plains or as extensive, shallow basins; occasionally, as low, wet flats adjacent to streams and lakes, and now often as abandoned strips of a once fertile ranch. The latter are due to the accumulation of alkali carried to the lands by the irrigation waters or leached from the soils of the adjacent slopes. How to secure from such ranch lands profitable crops and from the larger alkali districts, forage of value are questions worthy of consideration.

RELATION OF PLANTS TO ALKALI.†

A question needing full investigation is the relation of plants to alkali or other salts in the soil. Practically all that we know is that some species have adapted themselves to endure or even to thrive in soil containing greater or less amounts of various salts; that the seeds of most plants will not germinate in alkali soils because they are unable to absorb enough of the denser water of such soils. It has been shown that alkali retards germination or entirely prevents it in most seeds in direct proportion to the amount of the salt present [*]

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*The management of pasture lands and of the open range must vary in many respects. Little can be done for the improvement of lands which are not under individual control. Data are being accumulated regarding crop and pasture grasses and the treatment that each should have to give the most favorable results.

†This and the next two topics have been in part adapted from the writer's report upon the Red Desert of Wyoming.

Different species even in the same genus behave very differently in this respect; for example, Lambsquarters (*Chenopodium album*) seeks a soil free from salts, while for the Glaucousleaf Lambsquarters (*C. glaucum*) there can hardly be too much. If alkali affects a plant injuriously it seems to do so throughout its whole development.

Only a few families of plants contain species which have adapted themselves to a saline soil. Easily first as to the number of species in this respect is the Goosefoot Family (*Chenopodiaceae*). To this belongs a large number of distinctively alkali plants, such as the Salt-sages, White-sage, Greasewood, Russian-thistle, Australian Saltbush, etc. All of the native forage plants that are tolerant of alkali are contained in about a half dozen families. Besides the one already mentioned the next most important are the Grass family (only a few species) and a few species in the Sedge, the Rush, the Thistle (Compositae) and the Pea families.

VALUE OF ALKALI PLANTS AS FORAGE.[†]

The notion that often prevails that the small shrubs and weedy-looking plants of alkali lands have little forage value is an error. Inferior they may be to some of the choicest grasses but they are equal to many of the grasses and sedges that are cut for hay. As winter forage they are far superior to most of the grass-like plants after frosts have struck these down. As proof of this note the magnificent results that are attained in the Red Desert* the great winter pasture of Wyoming. If the winters are not too severely cold nor the snow too deep, all kinds of stock not only subsist upon these plants but actually remain in good flesh throughout the winter. These plants are much more succulent than appearances would indicate. Growing on strongly saline or alkaline soils, the Salt-sages and many other plants take up these salts in such quantity that one readily detects them on tasting even a small fragment of a leaf. Stock, feeding upon such plants, secures the necessary amount of salt from the food, so that the salting of stock that must be resorted to during the months when the animals are feeding upon the mountain grasses is wholly unnecessary.

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[*] Bulletin 29. Wyoming Expt. Station. by Prof B. C. Buffum.

[†] For an excellent summary of what is known of the relation of plants to alkali, and of the value of alkali-tolerant forage plants, see Forage Plants for Cultivation on Alkali Soils, by Jared G. Smith, in Yearbook of Department of Agriculture for 1898. The Experiment Station of the University of of California has also studied exhaustively many of the questions pertaining to alkali soils and the plants adapted to them.

INCREASING THE FORAGE SUPPLY.

In the earlier paragraphs of this bulletin, attention was called to the fact that the expansion or even the maintenance of the present stock industry is dependent upon the possibility of increasing the total amount of forage. No attempt will be made to show how this may be done except as to the forage of our alkali lands.† On the large areas of these not much may be hoped for by the expenditure of any ordinary effort or means but nature will here do much to bring about the desired result. According to the best information obtainable from many of our closest observers, the amount of forage produced each year is perceptibly increasing in some of the largest alkali areas of the state. In these localities the forage chiefly depended upon is shrubby in its character. The cutting down to the ground of such vegetation enormously increases the number of annual shoots.

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*For a full discussion of the alkali forage of the Red Desert of Wyoming see the writer's report to the U. S. Dept. of Agriculture, published as bulletin 13 of the Div. of Agrostology.

†Probably in some future bulletin the character of the forage and the means for its improvement on lands free from alkali may be discussed.

From winter to winter this shrubby vegetation has been browsed down closer and closer to the woody bases of the plants, until now the tender annual shoots are produced in much greater abundance. The effectiveness of this browsing is, of course, dependent upon the region being used as a winter pasture only, giving time for growth and recovery each summer. If we so treat alkali plants of the greater plains that they shall have a chance to increase where they already occur, introduce them into the saline soils where they are not now found and, if possible, irrigate those that will respond to this attention by an increased yield, we shall see a marked difference in the stock-supporting capacity of the state.

Much can be done to make profitable the enclosed lands that originally were alkali lands or have become so through irrigation. Though they are generally considered worthless, yet highly satisfactory returns may be secured from them if they can be successfully seeded to alkali-tolerant plants. The kind of plants introduced will determine whether the crop may best be harvested or left on the ground as winter pasture.

The following brief list contains only such plants as are known to be more or less tolerant of alkali. Each is discussed with respect to this quality and as to its value as forage. Introduced plants that have proven of more or less value in some other places on alkali soils might be given but it is believed that the native forms are quite as likely to give favorable results, under the conditions existing here, as any of of the introduced ones.

THE SALT-SAGES.

Among the plants suitable for alkali soils, easily first are the Salt-sages or, as they are sometimes called, the Salt-bushes (Species of *Atriplex*). Many of these are exceedingly nutritious and constitute a large percentage of the forage in some of the arid, alkali plains. Some of them are reproduced each year from seed but many of them are perennials with merely a woody base or sometimes the whole plant quite shrub-like. The perennials are more valuable as pasture plants than the annuals, though they are more difficult of introduction, but, when once established, should yield without further attention forage of much value. Of the perennial species the following are of most importance for this state, as judged by their present relative abundance and adaptability to our alkali lands.

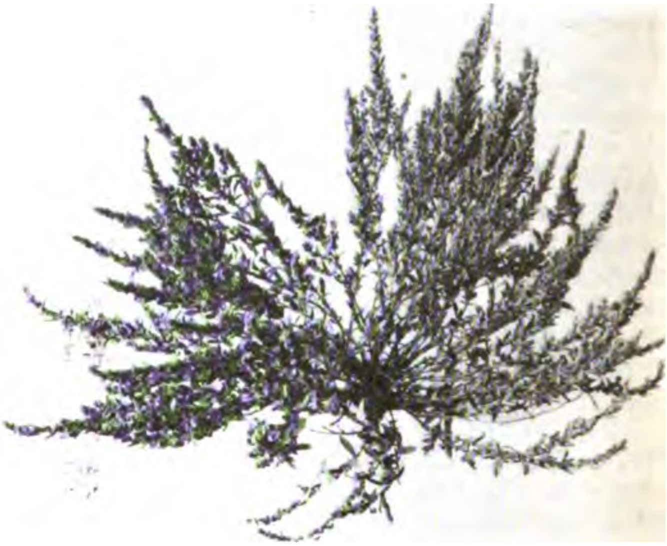

PLATE I.* Nuttall's Salt-sage (*Atriplex Nuttallii* Wats.).

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*I wish to acknowledge the valuable assistance rendered by Mr. A. H. D
preparation of the photographs from which these illustrations were made.

Perennials.

NUTTALL'S SALT-SAGE,—Plate I and Fig. 1, Plate III. (*Atriplex Nuttallii.*) This is by far the most widely distributed of the Salt-sages, being common throughout the interior arid west. It is less tolerant of alkali than the following species, occurring principally in soils where salts occur in moderate amounts only. It is essentially a plant of the greater plains where it sometimes occurs in the greatest abundance. Especially for sheep it has no superior as winter forage. From its woody base it each year puts out a large number of stems which spread loosely in all directions. These are seldom more than a foot long, are quite leafy below and produce a great abundance of very nutritious seed. Its deep set roots and woody base enable it to endure much hard usage but these characters in connection with its slow growth make it unsuited for any use except permanent pasture. It is difficult of introduction but where well established care should be taken not to destroy it. Seed, however, is readily obtainable.

OSTERHOUT'S SALT-SAGE,*—Fig. 2, Plate III (*Atriplex eremicola*). This species resembles the preceding in many respects but it has a heavier, harsher woody base, is more erect in habit, grows to about the same size and has probably about the same forage value. The advantage that it enjoys over the preceding is that it is more tolerant of alkali, apparently thriving best on the borders of lakes and ponds where the surface is quite encrusted with the salt. In soils where the preceding will not grow this might be substituted were not the following a far more promising species.

NELSON'S SALT-SAGE,—Plate II and Fig. 3, Plate III, (*Atriplex pabularis*). Of the native perennials this is the one most worthy of trial as a crop plant. So far it is only known from south-central Wyoming where it occurs in greater or less abundance in the vicinity of alkali lakes and on the banks of similar creeks, e. g., Bitter Creek, in the Red Desert. Unlike the two preceding, its woody base is almost wholly underground, the numerous annual stems are nearly erect, very leafy and decidedly herbaceous in

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*In habit this so much resembles the preceding that no illustration of it as a whole has been introduced.

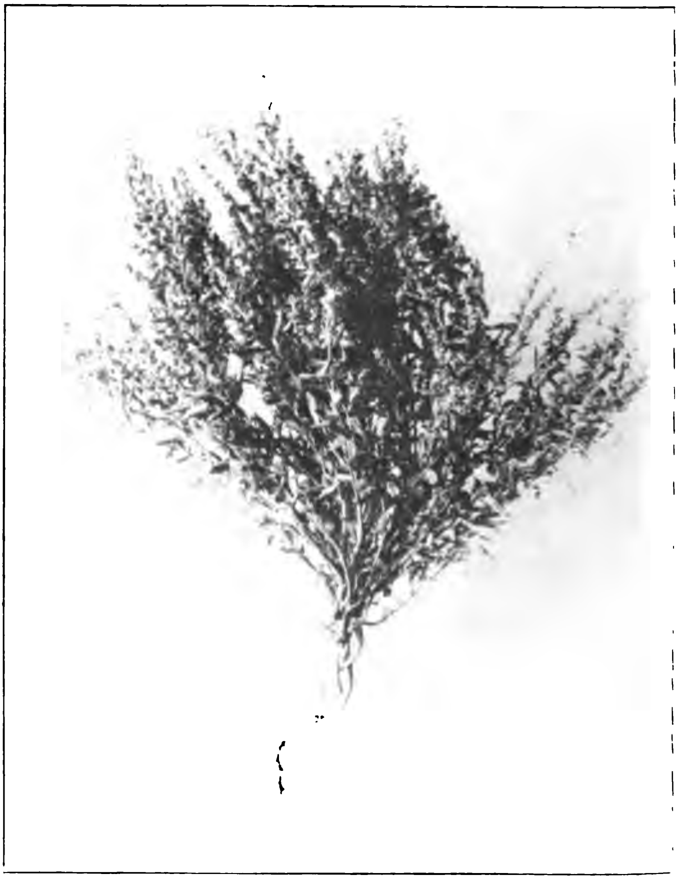

PLATE II. Nelson's Salt-sage (*Atriplex pabularis* Aven Nelson).

character. It also differs from the others in the close, continuous growth that it makes but resembles Osterhout's Salt-sage in that it is at home on the strongest alkali soils. Though best suited for a pasture plant, yet its erect habit and the herbaceous nature of the stems make it possible to harvest a crop of this with the ordinary machinery.

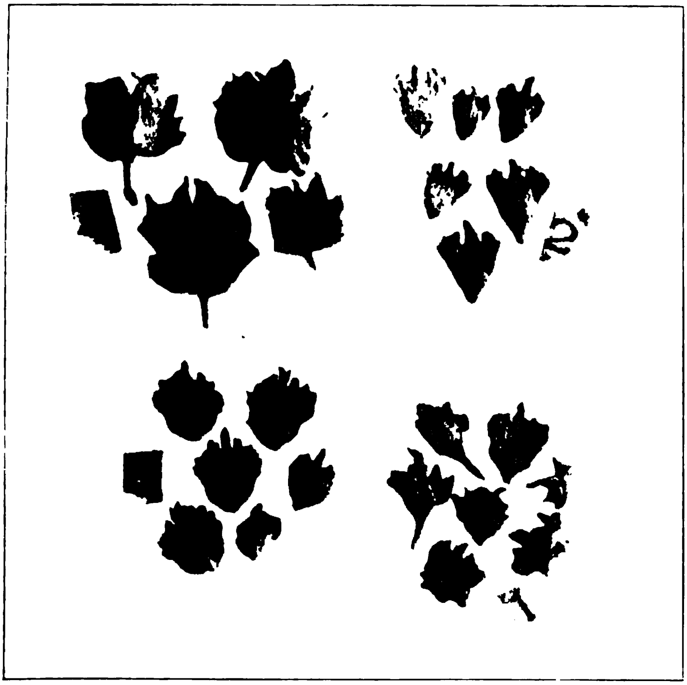

PLATE III. Seeds (technically fruits) of some perennial Salt sages: 1. Nuttal's Salt-sage. 2. Osterout's Salt sage. 3. Nelson's Salt-sage. 4. Bushy Salt-sage.

BUSHY SALT-SAGE.—Fig. 4, Plate III (*Atriplex canescens*). This species of Salt-sage is decidedly woody, sometimes a shrub several feet high. Its leaves and abundant seeds are greatly relished by all browsing animals, so much so that it is being largely exterminated where it is accessible to stock at all times of the year. It is not abundant in Wyoming, belonging rather to a range to the south and west of this state. On account of its shrubby character it can hardly be recommended for introduction.

Annuals.

Some of the annual species are very tolerant of alkali, grow rapidly, often forming plants of great size, and produce seed in the utmost profusion. It is doubtful if the forage value of these is equal to the perennial species and as winter pasture they have little value. On strongly saline soil where nothing else will grow and from which prompt returns are desired these may be properly tried. To secure the best results the crop must be harvested just before maturity in order that the seed may be retained. Of the several species in the state the three briefly describel below are the most promising.

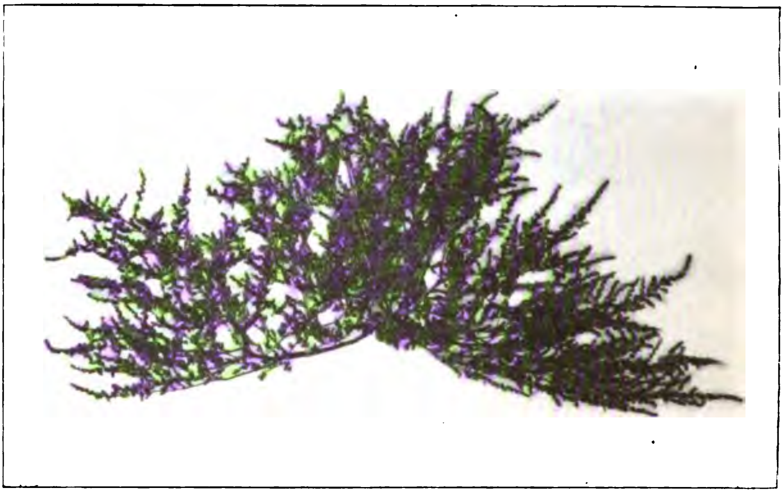

PLATE IV. Spreading Salt-sage (*Atriplex expansa* Wats.).

UTAH SALT-SAGE,—Fig. 1, Plate V (*Atriplex truncata*). This branches rather freely from the base, its branches spreading loosely in all directions and producing a wealth of succulent leaves. It is less tolerant of alkali than the two following but is very generally distributed on the arid, alkaline plains. It is probably more readily introduced than the plants that are native on the more strongly impregnated soils.

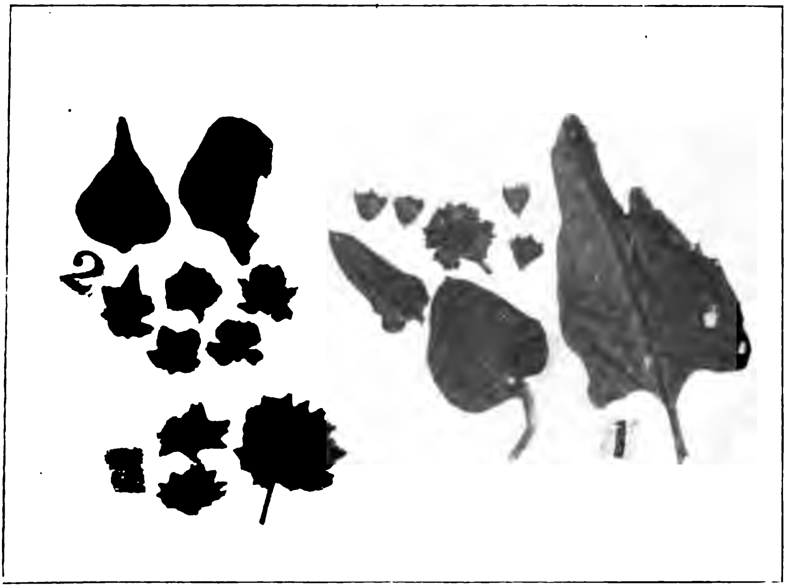

PLATE V. Seeds (technically called fruits) and leaves of some annual Salt-sages: 1. Utah Salt-sage. 2. Spreading Salt-sage. 3. Tumbling Salt-sage.

SPREADING SALT-SAGE,—Plate IV and Fig. 2, Plate V (*Atriplex expansa*). Very similar to the last but more freely branched and with much smaller, somewhat triangular leaves. This occurs on soils often quite encrusted with alkali, makes a dense and vigorous growth and yields a large quantity of fair forage which, like the preceding, must be harvested before it becomes dry and brittle.

TUMBLING SALT-SAGE,—Plate VI and Fig. 3, Plate V. (*Atriplex volutans*). In this plant we have a typical tumbleweed. It branches so freely and intricately that by autumn it is a dense, subspherical mass. At maturity the slender tap-root becomes brittle and soon breaks, after which the plant is rolled hither and yon by the winds, scattering its seeds at every bound. It does not seem to be widely distributed, being scarcely known except in the alkali basins and on the shores of alkali lakes. On lands that have been abandoned because of progressive accumulation of alkali this may prove to be just the desired plant. If sown thickly it would shade the ground, preventing further rise of the salt, absorbing much of it in its growth and producing at

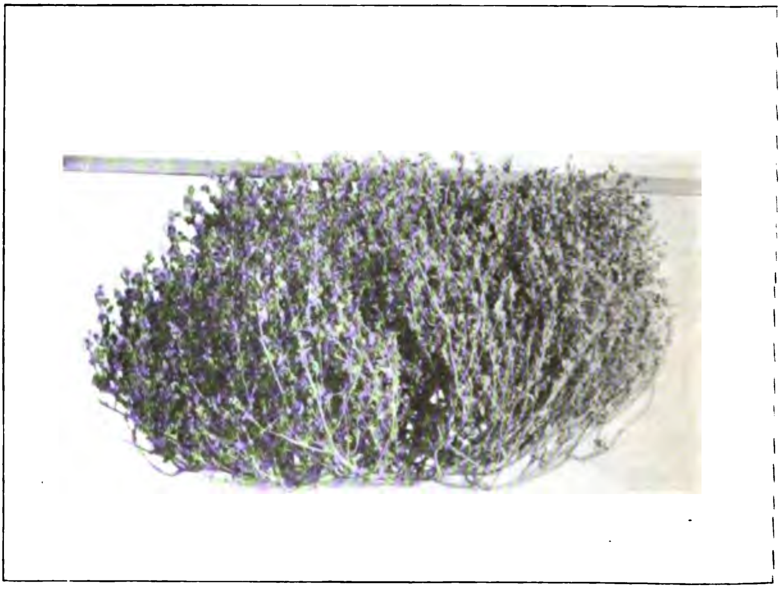

PLATE VI. Tumbling Salt-sage (*Atriplex volutans* Aven Nelson).
The meter stick lying on top serves to indicate the size of the plant.

the same time a great amount of coarse forage. If harvested a little before maturity and preserved in a silo it would probably yield a superior product.

WINTER-FAT.

WINTER FAT,—Plate VII and Fig. 1, Plate VIII. (*Eurotia lanata*). In this near relative of the Salt-sages (sometimes called Sweet-sage) we have another plant that is tolerant of alkali and of much value as a pasture plant. Though it is widely distributed in the state yet it is not now very plentiful since stock seek it so eagerly that it is becoming exterminated in many places. The numerous herbaceous branches which spring from the woody base are rather densely white hairy and become during the season about a foot long. These are often literally loaded down with the characteristic, white cottony seeds. It thrives on cultivated ground, makes a rapid growth and provides winter pasture of great value, especially so since (so it is said) stock feeding upon this plant are remarkably free from disease on account of its tonic properties.* Since it is not difficult to find small patches in enclosed grounds from which seed may be obtained ranchmen will no doubt find it worth their while to give this valuable plant a trial.

THREE GRASSES.

Among the native species of grasses there are very few that can be recommended for cultivation on alkali soils: There are several species that will exist in such soils but only a few that will prove profitable as pasture or crop plants.

INDIAN MILLET,—Plate IX and Fig. 2, Plate VIII (*Eriocoma cuspidata*). This is not strictly an alkali grass. In fact it will not endure soils containing a very large percentage of salt. It is included here because it is one of the import-

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*Yearbook of the Dept. of Agriculture, p. 547, 1898.

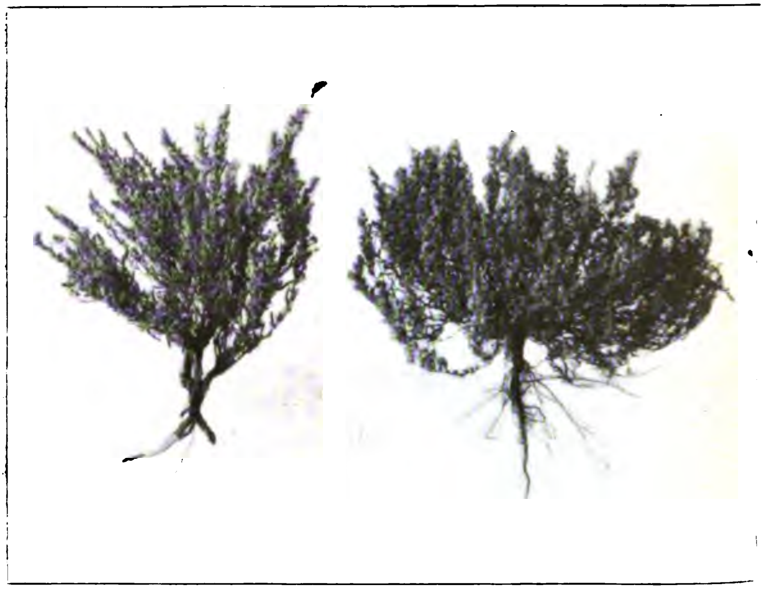

PLATE VII. Winter fat (*Erotia lanata* (Pursh) Moq.).

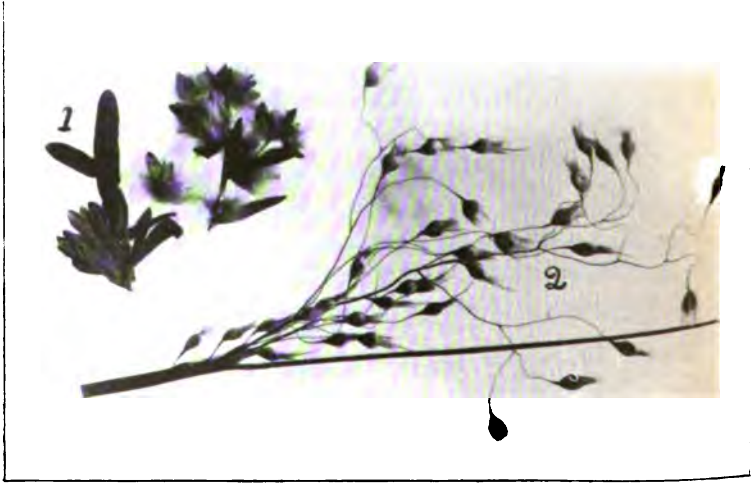

PLATE VIII. 1. The tips of two branches of Winter-fat. 2. Head of Indian Millet.

ant pasture grasses on the dryer alkaline areas of the interior west. It is one of the bunch-grasses, forming dense tufts from a few inches to a foot or more across. In no region is it so dry and sterile that it will not live but in better soil and with more moisture it becomes even prolific. Often but a few inches high yet under favorable conditions it attains the height of a foot or two. In any case it fruits abundantly and may be easily known by its large, peculiarly branched spreading panicle and large silky seeds. All

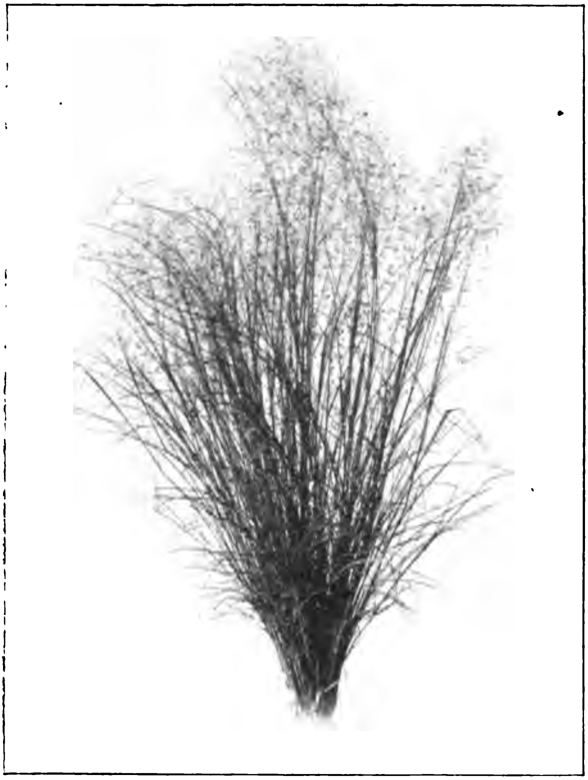

PLATE IX. Indian Millet (*Eriocoma cuspidata* Nutt.).

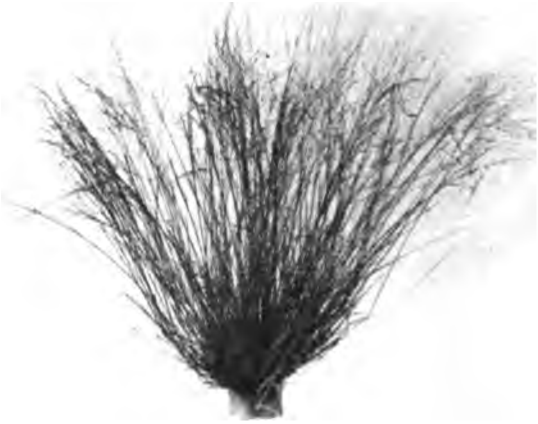

PLATE X. Alkali Meadow-grass (*Puccinellia airoides* Coult. & Wats.).

kinds of stock relish this plant but horses are especially fond of it and seem do well upon it. It is easily grown from seed as it germinates readily and reaches its best development in loose or sandy soil. It is often adventive in cultivated ground and on the loose slopes of railroad embankments.

SLENDER WHEAT-GRASS,*—Fig. 1, Plate XI. (*Agropyron tenerum*). Among the native grasses of the west there are none that will surpass in value the Wheat-grasses. Many species of these not only grow luxuriantly but represent forage of very high nutritive value. Several species are tolerant of alkali but, as it happens, the one that is best adapted to soils of this character is also in many other respects the most desirable as a meadow grass. Slender Wheat-Grass makes a meager growth in dry sterile soil, but it responds promptly to all cultural advantages. The writer has seen wonderful results from seeding the ground to this grass, and this, too, where the soil was strong with alkali and the water used for irrigation was far from the best. It forms a close uniform growth that yields as much per acre as an average field of Timothy. Since it thrives best with a very moderate amount of water (it will not endure flooding) no more profitable grass can be found for saline areas of limited water supply. While not seeding very freely, the requisite amount for sowing can easily be obtained after the first crop has been harvested. It is easily thrashed out in a machine or may be flailed out if no better method is at hand. Seed of this grass is now on the market.

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*The Wheat-Grasses are so well known that no illustration is considered necessary except one of the head of this species. By this, it may be distinguished from the other species.

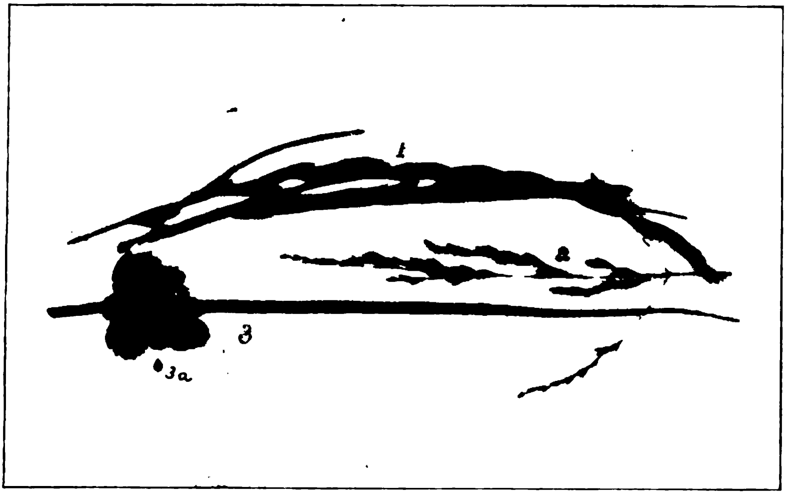

PLATE XI. 1. Heads of Slender Wheat grass. 2. Head of Alkali Meadow-grass. 3. Head of Tuber Bulrush. 3a. A single seed of Tuber Bulrush.

ALKALI MEADOW-GRASS,—Plate X and Fig. 2, Plate XI (*Puccinellia airoides*). Here we have a grass that is at home on the salt encrusted margins of ponds and lakes and on wet efflorescent flats where other grasses are wholly wanting. In such situations it grows luxuriantly, making a crop of much value but for the difficulty of harvesting it. Though of less nutritive value than some other grasses yet if cut in its prime it would make tolerable hay. Browsing animals greedily devour it but often it grows in boggy, inaccessible places. On abandoned alkali flats which can be flooded early in the season but which can be entered later with horses and mower this should be a profitable crop.

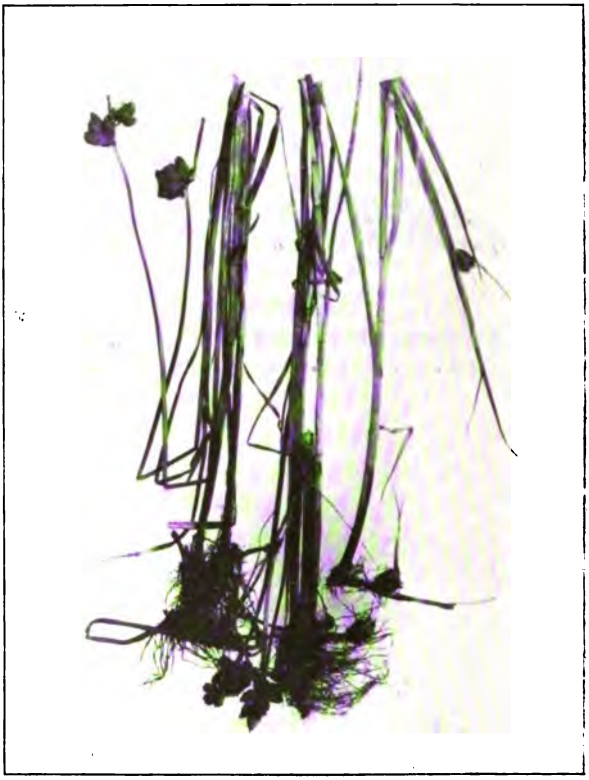

PLATE XII. Tuber Bulrush (*Scirpus paludosus* Aven Nelson).

It produces a fair amount of seed but unless harvested promptly, as it nears maturity, much of this is lost. Even as a pasture grass it has little value after it has reached maturity.

BULRUSHES.

Though there are several Rushes and Bulrushes that occur in alkali soils and have some slight forage value, yet there is but one known to the writer that is sought out by stock when other feed is abundant. This is the

TUBER BULRUSH,—Plate XII, and Fig. 3, Plate XI. (*Scirpus paludosus*). It never reaches maturity if it is accessible to cattle. They will wade about for it in places where they are in imminent danger of becoming mired. Like the grass last described above it will thrive best where the alkali is the densest. Even on recently dry lake beds, covered inches deep with the white salt, this species still develops apparently uninjured. Its best development is attained in alkali marshes that become dry late in the season. In such situations, if stock be kept out, it makes a dense, uniform growth and attains a height of 18 to 24 inches. Leaves are produced in abundance and the head-like cluster of spikelets are so richly supplied with large plump seeds that it is an easy matter to collect quarts of them by hand in a few hours. Though the seeds are retained by this plant most remarkably well yet none are more easily thrashed out and cleaned than this.

To secure perpetual returns from lands so thoroughly filled with alkali as to be worthless as regards other crops seems more than possible if seeded to this. Being an herbaceous perennial of the most persistent character it should maintain itself indefinitely where it is once introduced. Each year's new stems spring from the tubers produced the previous year at the end of short underground stems, and by this character and mode of development this species may easily be recognized.

UNIVERSITY OF WYOMING.
Agricultural College Department.

WYOMING EXPERIMENT STATION,
LARAMIE, WYOMING.

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MARCH, 1900.

ALFALFA AS A HAY CROP.

ITS CULTURE AT HIGH ALTITUDES.
TURKESTAN ALFALFA.
ALFALFA AND ALKALI SOIL.
IRRIGATION OF ALFALFA.

BY B. C. BUFFUM.

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ALFALFA.

(*Medicago sativa.*)

B. C. BUFFUM.

Much has been written about alfalfa in other states. Station literature, reports of Boards of Agriculture and the agricultural periodicals contain many accounts of experiments in growing, and investigations of the value of this forage. No other plant which has been widely grown in the arid region is held in such high esteem by those who have had the largest amount of experience in irrigation farming. The ease with which it is grown, its hardiness under trying conditions, the large yields produced year after year from a single planting, its distinctive value as a fodder and its power of improving the soil upon which it grows to such an extent that no expensive means of keeping up fertility is necessary, has brought alfalfa near to the hearts and pocket books of intelligent farmers and makes it a boon whose value can not be estimated.

In this bulletin it is not our purpose to give an account of experience with alfalfa in other regions, but to report briefly the results of our own investigations; indicate methods of culture which will insure success and give information of the return that may be expected under our own peculiar conditions of soil and climate. The question of raising alfalfa at altitudes under six thousand feet in the state, where it can be irrigated, is a comparatively simple one. It will grow on poor soil if in good tilth, not too strongly alkaline and with good drainage, and when once established it only requires irrigating and harvesting from two to four times each season. As the altitude increases and conditions become less favorable more care is required to secure a stand and over seven thousand feet above the sea, in dry and naturally exposed positions, specific treatment must be given to insure success. By the term "specific treatment" we would not convey the impression that great expense must be incurred to secure a productive meadow or that any practice which is beyond the ability and means of every ranchman is necessary. We have demonstrated that alfalfa can be raised on the Laramie Plains at small cost and that the resulting crops of hay will be remunerative to the man who exercises as much care and judgment as he would to raise a crop of oats.

Several ranchmen who first attempted to grow alfalfa on the Laramie Plains failed because they used wrong methods of preparing the soil and sowing the seed or because the crop was left to care for itself after sowing. From these failures the belief became widespread that making a success of raising alfalfa at this altitude, under our conditions of exposure, drying winds and short seasons, was out of the question. When the Experiment Station was established at Laramie I was warned by one of our large ranchmen that any attempt we might make to grow alfalfa would surely result in failure, and that it would be unwise for us to spend any of the station funds in experiments with it. This ranchman stated that he had spend five hundred dollars in his efforts to grow alfalfa on his ranch and was fully convinced that we would never be able to produce alfalfa hay in this region. When questioned in regard to the method he had pursued he said the ground had been carefully prepared by plowing, the alfalfa seed had been sown broadcast and harrowed in, but none of it grew.

Our first attempt to grow alfalfa on the station farm in 1891 failed.* The seed was planted on sod the first year it was plowed. With the seed was a goodly supply of dodder, a parasite which destroyed the young alfalfa plants. Some alfalfa seed sown on sod without plowing also failed, but since that time many plats and fields have been planted to alfalfa and we have not had occasion to record another failure. After we had been growing alfalfa for a number of years and had good fields of it close to the county road to demonstrate to passers by that it was successful, many ranchmen were still suspicious, and unfortunately, at the present time, some seem to entertain the idea that we have followed some secret or expensive system of culture to make it grow. They believe that our flourishing fields are deceptive and that it is beyond their power to secure like results. Only a year ago one ranchman who had become convinced from what he saw and what we told him of our experience, that alfalfa was a practical crop to grow, applied to a merchant in Laramie for some seed to be sown on his ranch. The merchant assured him that he could not afford to coddle his alfalfa, as he said, "go out and cover it up nights, the way they do on the Experiment Farm," persuaded him to give up the attempt to grow it himself and, I believe, sold him seed of alsike or something else which had not been demonstrated a success here. He has lost a year's growth of alfalfa and we are informed, regrets that he planted alsike.

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*See Bulletin No. 16, Wyoming Experiment Station, "Grasses and Forage Plants," page 232.

To trace the reason for such a prejudice is difficult and it is only necessary to say that such ideas are based on complete misconception of the purposes for which the station is established and supported. The experiment stations are established and operated for a single purpose and that is to benefit the farmers by investigating the problems in which they are interested and can not afford to investigate for themselves. But one thing is asked in return and that is that the results of these investigations be accepted and made use of by the farmer for his own personal pecuniary advantage.

The range stockman of a dozen years ago could make use of thirty or more acres of public domain for the support of each steer. He drifted away from the habit of tilling the soil and became constitutionally opposed to that occupation. The palmy days of the open range are gone and the inevitable may as well be accepted, that as land becomes scarce that which can be irrigated will be cultivated. It has become necessary to support each head of stock on a small fraction of the land which was formerly available. Irrigating native meadows has greatly increased the production of wild hay. Substituting such cultivated forage crops as alfalfa will double or treble the production of hay and the prosperity of the ranchman and farmer who makes proper use of his products will correspondingly increase.

ALFALFA CULTURE.

The culture of alfalfa is simple, but failure often results from wrong treatment. Under favorable conditions no crop is more easily grown, but there are correct methods of procedure in alfalfa culture which it is important to know and make use of everywhere. Under our high altitude conditions, the farmer who would be sure of his success must sow his alfalfa seed on the right kind of land and in the right way; have the soil properly prepared and give the crop that attention afterward, which will prevent its dying from drouth, or from excess of water, or succumb to any of the ills due to pure neglect. The farmer should remember that alfalfa has been a cultivated plant longer than the history of the Christian era, having been cared for by man for over

2,000 years and introduced into parts of the world widely differing from its native home.*

Although it is a perennial plant it has little more tendency to go wild after planting, and care for itself under our conditions, than wheat, which everyone understands would be lost to the world if not cultivated by man. However, alfalfa is one of the hardiest forage plants known. It will adapt itself to widely differing conditions. When a stand has once been secured, it resists drouth remarkably well, will stand as much or even more heat and cold than other cultivated plants or our native grasses and will last longer under contινous cropping than will the best native meadow, producing each year from two to four times as much hay. As alfalfa is one of the easiest crops grown at low altitudes, farmers as a rule do not practice the careful methods here outlined, but it is just as inexpensive to follow a right method as a wrong one and ultimately is much more profitable. At high altitudes where the growing season is short, the nights cold and the winters long and dry, specific treatment becomes necessary to insure success. The hints for its culture here given are especially for high altitudes, though they are generally applicable to all portions of the state.

KIND OF SOIL—Alfalfa thrives on any good soil and in some places on comparatively poor soil, though it prefers a warm, sandy loam. Instead of recommending soils and locations for alfalfa we will briefly point out three or four things to avoid. Do not plant alfalfa seed in soil so strongly impregnated with alkali that there is a white incrustation of salt on the surface during part of the year. (See discussion of alfalfa and alkali soils on another page). Do not sow seed on low land where the drainage is not good. Alfalfa will not live where free surface water stands as near the top of the ground as one or two feet·and any attempt to grow it on low, wet soils will result in failure. Water standing around the plants for any length of time from to much irrigation will surely destroy them.

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*Alfalfa is a Spanish name said to be derived from an Arabic word meaning the best fodder. In Europe it is known as lucerne, but originally this species was probably a native of some part of Asia. Its scientific name, Medicago, comes from the Greek, Media, a country which extended east to the Caspian sea. It was introduced into Rome from Media about 470 B. C. From there it spread into Spain and the Spaniards brought it to Mexico about 1520. Nearly fifty years ago it reached the United States by being introduced into California from Chili, South America.

Alfalfa is a deep feeder. Usually it will not do well on a shallow soil underlaid with hard pan which prevents the strong tap roots from going deep into the subsoil. We have grown several good crops of alfalfa on land which had only from twelve to eighteen inches of surface soil, being underlaid with hard pan composed of gypsum and lime. This land has good slope and drainage. While good crops have been secured it has been necessary to exercise great care in irrigating and a large amount of water, or rather numerous irrigations, have been required to keep the plants from suffering, as the roots could not reach deep into the soil for moisture. A shallow soil over sand or gravel which both provides good drainage and allows the roots to sink deep into it, would be better than the same soil underlaid with hardpan. Many ranchmen have inquired whether or not we would recommend planting alfalfa on bottom lands along the river. As a rule we believe upland is to be preferred, as the soil is usually deeper and better drained. If the bottom land is comparatively free from alkali, and the surface is not too near the water level at any season of the year, alfalfa will succeed, and when it has become well established will probably require less irrigation than on upland, as the roots will go down far enough to reach the moisture supply below.

PREPARATION OF THE LAND.—Much depends on the condition of the soil upon which seed is sown. Alfalfa

Alfalfa. Loading on wagon, Laramie, 1899. Wyoming Experiment Station.

Stacking Alfalfa. Wyoming Experiment Station, at Laramie

seeds are small and the soil should be correspondingly well prepared, fine and moist. We do not recommend planting alfalfa on sod land under any conditions. At low altitudes in this State a good stand may be secured the first year after breaking up the sod but I have never known of such an instance at altitudes over six thousand feet and it will probably never pay to sow the seed on stiff or heavy sod which has not been plowed. An alfalfa meadow is practically permanent and will well repay the expense of preparing the soil and sowing the seed in the right way. If a piece of sod land is to be converted into an alfalfa field it should be plowed and planted to oats or some other crop the first year or two in order to put the soil into the right physical condition for the alfalfa seed. We think it best to have the soil somewhat compact for the seed and find it better not to sow alfalfa on newly plowed ground. A good stand of plants will be secured with more certainty on land which has been fall plowed or on stubble which is merely disk-harrowed and planked and again lightly harrowed to form a thin top mulch of loose soil which will prevent the rapid loss of water by evaporation. In case it is desired to sow alfalfa on land which is plowed the same spring, plowing should be done as long before sowing as possible, and the newly plowed soil may be rolled or heavily planked to compact it and afterward lightly harrowed to leave the surface finely pulverized. On loose, newly plowed land there is danger of drilling the seed too deep and the crop will fail because the small seeds are unable to push out of the ground.

Young alfalfa plants are quite tender and must be given no rough treatment until they have become well established. Should the soil be too dry to germinate the seed it may be irrigated to bring the plants up if carefully done and the land does not slope so much that the soil will wash away. If there is danger of the soil becoming too dry to germinate the seed and support the plants during the first two or three weeks of growth, irrigating should be done before plowing the land and the moisture saved as long as possible by harrowing after plowing or rolling the soil. We have never failed to get the seed to come up without irrigation where sown with the press drill.

While alfalfa has the power to take nitrogen from the air and will grow on very poor land, at least that which is poor in humus, as is often the case with our arid soils, we know of two instances on the Laramie Plains where the young plants were much stronger and made better growth the first year on land that was given a light dressing of stable manure. Mr. Webber sowed some alfalfa on land that had been manured and thinks the results more than paid the extra expense. On the Experiment Farm alfalfa made much stronger growth when planted on land that was fertilized with twelve loads stable manure per acre. The application of manure is not necessary, but where for any reason the struggle to become established is unusually great and such application can be cheaply made, the effect in producing strong young plants may well repay the extra trouble and expense. A strong point in favor of alfalfa is its power to grow on, and improve soils which have been worn out by other cropping.

WHEN AND HOW TO SOW THE SEED.—The young plants need to become as well established as possible, and have time to throw their roots deep into the subsoil for moisture, before going through the long winter. To enable them to do so the seed should be sown in the spring and as early as danger of hard frosts, which would destroy the young plants, is past. Another advantage of sowing early is that our spring months are our months of greatest moisture. Usually enough moisture comes to the land by rain to secure germination and provide for the early growth. On the Laramie Plains the seed may be sown any time in May. As the seeds germinate quickly it is probably safer to sow after the tenth of May than before that date. At altitudes in the state below six thousand feet, April is to be preferred, though the seed may be sown at any time up to July.

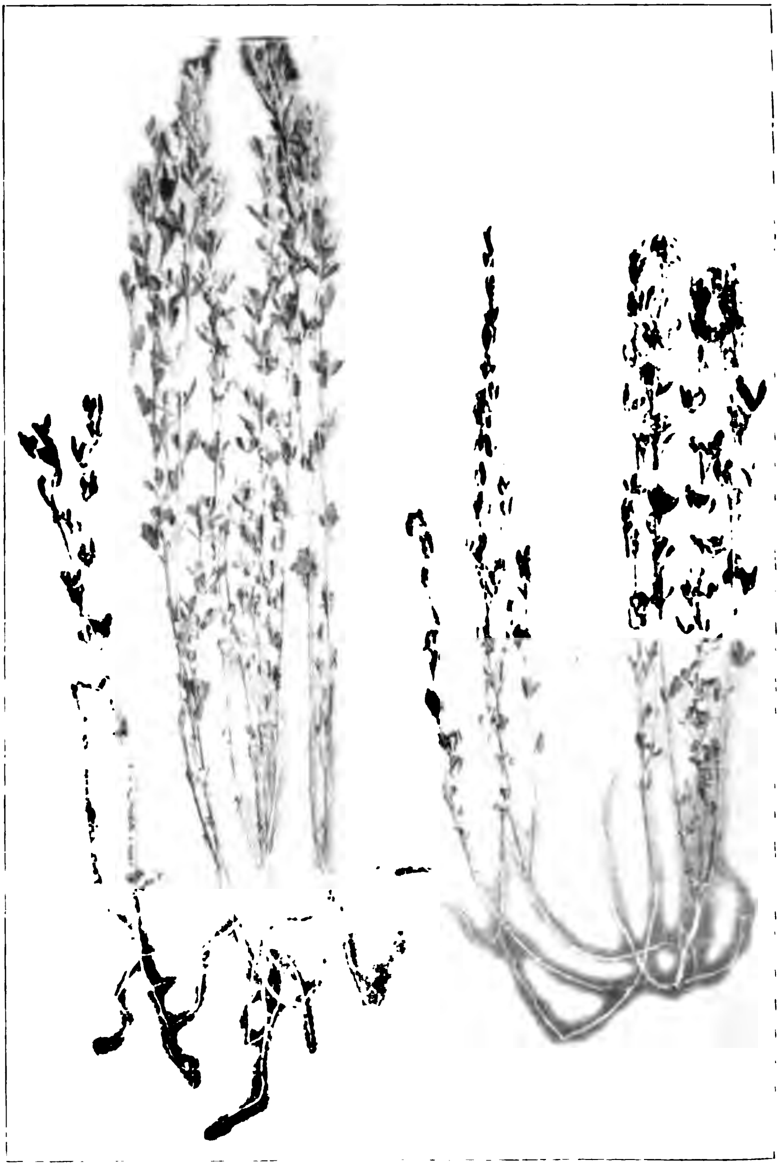
The seed should be sown from one-half to two inches deep. Because of the danger of the surface drying out I think it advisable to plant as deep as may be done with safety. This will vary somewhat with the kind of soil, but in general if planted more than three inches deep there is danger that the germinating plant will not be able to reach the surface. We have lost our seed once or twice by planting too deep.

A point of great importance is that the soil should be packed around the seed. Many failures to secure a stand of alfalfa are traceable to sowing the seed broadcast on newly plowed ground and harrowing to mix the seed loosely with the surface soil. Under favorable conditions of soil and moisture, alfalfa may be so grown, but sowing broadcast is hazardous at the best. Where sown broadcast from one-half to one-third more seed must be used to secure the same stand, as a large percent of it is either not covered at all or so lightly covered that it fails to grow. Alfalfa seed has been worth from six dollars to twelve dollars per hundred pounds for the last ten years. This means that from one-half to two or three dollars' worth of seed is thrown away on each acre of land where sown broadcast and harrowed in. If a seed drill can not be obtained, and it is necessary to broadcast, it should be thoroughly harrowed in, then rolled and lightly harrowed again. Undoubtedly the best machine for sowing alfalfa (and for that matter any other small seed in our soils), is some form of the press drill which distributes the seed evenly and presses the soil firmly around it. Thus the seed is planted to the right depth, and the moisture of the soil is brought in contact with it, which insures germination and growth. We feel that too much can not be said in favor of the press drill. If a ranchman had fifty or one hundred acres to sow to alfalfa or if he sows any amount of grain, sixty or seventy dollars for one of these drills would be a paying investment.

At the start it is well to expect to take two years to get a good stand of alfalfa and bring it into producing condition. The second spring the meadow or at least parts of it should be resown unless a uniformly good stand is secured over all the land the first year.

AMOUNT OF SEED.—The amount of seed to sow depends on local conditions, the kind of seed purchased and the purpose for which it is to be grown. Two kinds of seed may be obtained on the market. First quality seed should be heavy and plump, clean, of uniform size and color. "Second" is lighter seed, usually obtained from fanning and screening when the seed is threshed, contains much under ripe, green colored, shriveled grain and may not be free from weed seeds. For higher altitudes at least only the best seed should be purchased. Where the soil and climate are most favorable and the plants become sufficiently strong to withstand weeds during the summer and the cold of the first winter, second quality seed may do well enough, though it is always safe and advisable to get the best. About twice as much seed should be sown where the crop is to be raised for hay as would be used if it is intended to raise seed. We doubt if it will pay to raise alfalfa seed in Wyoming where the altitude is above 6,500 feet, as the season is short and the yield of ripened seed would be very small. For hay we believe in heavy seeding.

The thicker the plants are on the ground the better the yield and the finer will be the stems, which makes the



Alfalfa with and without Nurse Crop. Large plants show growth first season from seed sown alone. Small plants grown with Oats. Wyoming Experiment Station.

hay of better quality. The best plat of alfalfa raised on the Experiment Farm at Laramie was sown with forty pounds of seed per acre. This amount is excessive, however, and more than need be sown to secure the best results. From twenty-five to thirty pounds per acre should be sown the first year and if the stand is thin five or ten pounds may be sown over it the next year. Where the growth is thick in some places and thin in others, only the thin spots need be resown the second year.

SOWING WITH VS. WITHOUT NURSE-CROP.—A common practice is to sow alfalfa with some other crop, usually oats. The claim has been made that the young alfalfa plants are shaded and protected by the oats so they become better established than when planted alone, and of course a crop of oats is obtained at the same time. Where alfalfa is planted alone, small or no return is made from the land the first season after planting. However, the nurse crop does retard the growth of the alfalfa, because it robs the small plants of a large amount of moisture and sunshine.. At low altitudes, where alfalfa is perfectly hardy and will make a crop on any soil under almost any kind of treatment, it may be planted with light seeding of oats, barley or wheat. Where there is any difficulty or question about establishing an alfalfa meadow the nurse crop should not be used. To determine the effect of planting with or without a nursecrop, some experiments, have been carried out at Laramie. In 1897 a plat was divided in two parts, one of which was sown to alfalfa with a nursecrop of oats and the other without oats. Sixteen pounds of alfalfa seed per acre was used on each portion of the plat. Our illustration made from a photograph of average plants taken from each part of the plat in the summer shows the difference in growth the first season. The plants were more thrifty, larger and stronger where grown alone. Table I gives the results in yield per acre for 1898 and 1899.

TABLE I.—*Alfalfa with and without Nurse Crop. Laramie.*
Sown 1897.

	1898			1899			Average Yield Two Years		
	Date	Sown with Oats	Sown without Oats	Date	Sown with Oats	Sown without Oats	Sown with Oats	Sown without Oats	Gain in Hay in Two Years
		lbs	*lbs.*		*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
First Crop . . .	July 14	2557	4100	July 21	2596	2856	2576	3478	1903
Second Crop . .	Sept. 8	2842	3713	Sept. 11	1940	2040	2391	2576	971
Total.	. . . . .	5399	7813	. . . . .	4536	4896	4967	6054	2774
Gain	. . . . .	. . .	2414	. . . . . .	. . .	360	. . . .	1087	. . . .

This shows that the effect of sowing with the oats was felt by the alfalfa for three years after planting and reduced the average yield over one-half ton per acre, while in the two seasons nearly one and one-half tons per acre more hay was obtained from the plat on which alfalfa was sown alone. At Laramie prices it is doubtful if the oats secured would be worth as much as the value of the hay from the two succeeding crops of alfalfa, and they certainly would not pay if the injurious effects are more lasting than this in the alfalfa meadow.

In 1899 two other plats were planted with and without a crop of oats. They were planted June 15, using about twenty pounds of alfalfa seed per acre. The plat planted without oats was cut on September 11 and yielded 1,187 pounds of cured hay per acre. The hay contained a little volunteer grain and there was an occasional stalk of alfalfa from a previous seeding which increased the yield somewhat. The plat sown with Cape oats was harvested

August 18 and yielded 2,778 pounds of straw and grain per acre from which was threshed 792 pounds of oats. A fine stand of alfalfa was obtained on this plat which grew from one to two inches higher than the oat stubble in the fall. There was not so much apparent difference in the growth of alfalfa on the two plats as noted in 1897, but the final results can not be reported until more crops of alfalfa can be harvested. It should be said that the Cape oat is a very early variety which produces short straw and few leaves. It shades the alfalfa much less than the coarser strawed varieties and being cut early gives the alfalfa time to recover strong growth in the fall. It is not a heavy yielder but is very early, produces a short, quick growth and can be recommended for localities with short season and for planting with alfalfa where it is desired to grow it with a nurse crop.

WHEN TO CUT AND HOW TO CURE—Alfalfa should be cut when budded or just before it has reached full bloom. Experience in other places shows that the hay contains more nutriment at this time than before budding or after blooming. If allowed to go to seed the stems become coarse, hard and woody and lose many of the lower leaves. After cutting the plants grow rapidly and where the season is long may be harvested three or four times. With short seasons above six thousand feet altitude it will usually not be cut more than twice and on the Laramie Plains only the first cutting produces a full crop. The value of the hay depends much on the method and care used in curing it. Alfalfa can not be cured the way native hay is usually handled. After cutting it should be allowed to lie in the swath only long enough to become well wilted, when it should be raked into windrows where it may be left a few hours or a day before putting into cocks. Many rake in the evening what was cut in the morning of the same day. It should not be left long enough to become dry and brittle or many of the leaves will rattle off in raking, which reduces the value of the hay. Many use the rake for bunching the hay from the windrow, but it leaves the hay in loose, rough, tangled masses difficult to handle or manage if large, and the curing is not so well done as when the hay is made into cocks with the fork. Unless press of work or lack of help makes it necessary to bunch with the rake, cocking the hay by hand with the fork is to be recommended. The principal part of the curing is done in the cock, and when well done the hay does not lose its leaves, retains its beautiful green color, and will not must or spoil in the stack. Some experience and good curing weather are necessary to insure the hay being in the most perfect condition when it comes out of the stack. While perfection is difficult to attain there is little difficulty in obtaining a good quality of hay.

To show the amount of water lost in curing, we weighed the hay from one hundred square feet on acre plat 8, and again weighed it when fully cured and ready to go into the stack in 1895. The yield of green hay was at the rate of 24,874 pounds per acre, and of cured hay 6,540 pounds per acre, showing a loss of 73.7 per cent in weight before it went into the stack. Shrinking undoubtedly goes on for some time after stacking.

ALFALFA AS A HAY CROP.

The feeding value of alfalfa is recognized wherever it has been grown. Its composition and digestibility have been determined in many places and its nutritive and fattening qualities have been demonstrated in a practical way in every land since the Romans fed it to their horses. More study of its value compared with other fodders in our state will give more complete information than is possible for us to report at this time. We know something of its value, limitations and management from our own experience. The Station has carried out some experiments in stock feeding with alfalfa at Lander. The results of our first feeding trials there with cattle and sheep are reported in Bulletin No. 30 of this Station. In a later experiment which has not yet been reported cows were fed with alfalfa alone, with the best timothy hay, and with timothy and alfalfa mixed. Those fed alfalfa alone made larger gains than those given other hay. Some trouble was experienced with the alfalfa bloating the stock when allowed to eat all they would of the hay. Mr. Meyer, the Superintendent, attributed the trouble to close confinement of the stock, as he had experienced no difficulty with alfalfa where his cattle could exercise in the open.

The tendency of cattle and sheep to bloat on alfalfa, both in the green state when pastured or in the dry state when the hay is carelessly fed to stock not accustomed to it, is well understood and some caution and judgment must be exercised to avoid accidents of this kind which may result seriously. The writer has had experience in feeding alfalfa for many years and has never personally observed a serious case of bloating from feeding the dry hay. However we have known of others losing cows from such bloating but undoubtedly, in every case, it could have been pre vented. It usually occurs when animals which have not been accustomed to alfalfa hay are fed all they can eat of it when hungry, or perhaps when both hungry and thirsty, and then allowed to drink freely when their stomachs are distended with hay. Alfalfa is one of the most palatable fodders and animals which are hungry or those which naturally have greedy appetites, as Jersey cows, will gorge themselves with it if allowed to do so. Such animals should be fed sparingly until they become used to the diet, allowing plenty of exercise. If the animal does become seriously bloated from eating either the green or dry alfalfa, the timely use of the trocar will always save their lives. There is some difference between the different cuttings of alfalfa in its tendency to bloat cows. The first cutting is considered the best hay for horses and will not bloat cattle as readily as will cuttings made later in the season, though many now prefer second or third cutting for milch cows. At Laramie the first crop will cure in much shorter time than is required for the last cutting. The plants are less succulent and mature better in the first half of the season.

Poorly matured alfalfa when put into the stack too green or wet will become musty the same as other clovers. Feeding this hay to horses gives them a disease which farmers often call "heaves." True heaves is probably due to overfeeding such fodders while the trouble under consideration is undoubtedly a bronchial affection due to irritation produced by the dust. The animals soon recover as a rule when the dusty hay causing it is replaced by clean food.

Much interest is taken in the subject of pasturing alfalfa. Its use as pasture can be recommended for horses and swine, especially for the last named animals. The careful farmer who gives the subject intelligent personal attention may succeed in pasturing cattle and sheep on alfalfa without serious losses but our advice is to never use such fields for cattle and sheep pasture. It is dangerous to the stock and injurious to the alfalfa. On the Laramie Plains, and no doubt the statements are true for all high altitudes, at least, the young plants are not strong enough to stand long continued pasturing the first year after sowing the seed, and we believe much tramping injurious at any time. The alfalfa field has a hay producing power which gives it a value sufficiently great without trying to overdo the matter by pasturing it the remainder of the year. If cattle are allowed access to the growing alfalfa, however, it should be remembered that danger of bloating is especially great when the stock is first turned in the meadow, when the dew is on the plants, or during wet weather, or when the plants have been frosted. The farmer who takes these risks should ever have his trocar or sharp knife ready to save the life of his animals by puncturing the stomach to let out the accumulated gas. The difficulties we have mentioned are such as are experienced in Eastern states with clovers. They may be overcome by proper care and management and should not deter the farmer from growing and making profitable use of this plant.

YIELDS OF ALFALFA OBTAINED IN CROPPING EXPERIMENTS.

The yields we have obtained on the Experiment Farms will indicate the cropping qualities of alfalfa in the localities where it has been grown. The yield of hay produced at Laramie is of especial interest, as it shows the advantage of alfalfa over native hay at this altitude. It should be said that native grass will probably not produce an average of more than a ton of cured hay per acre, though it may yield as much as two tons or more in favored localities. Often the amount obtained is only a fraction of a ton per acre. One year on the Experiment Farm we obtained as much hay from a single acre of alfalfa as was produced on thirty acres of irrigated native meadow on an adjoining field. The native meadow here referred to was a very poor one and not worth cutting, but such results are often obtained the first year or two after irrigating to make them produce hay. That an idea of our average results may be obtained we report the yields from each field separately and of each cutting for the number of seasons the alfalfa has been grown.

TABLE II.—*Acre Plat 8. Alfalfa at Laramie. Area, 0.52 acre.*

Year	First Crop		Second Crop		Total Yield per Acre
	Date Harvested	Yield per Acre	Date Harvested	Yield per acre	
		lbs.		*lbs.*	*lbs.*
1895	Aug. 6	5019	Sept. 24	2557	7576
1896	July 7	1641*	Sept. 8	3040	4681
1897	July 16	3860	Sept. 9	3860	7720
1898	July 14	4759	Sept. 8	3909	8668
Average yield per acre. . .	. . . .	3820	. . . .	3341	7161

*Only partial crop, as it was injured by hail.

Acre plat 8 was planted in 1893 but failed to make a stand. Was given 12 loads manure per acre in winter, plowed up in spring of 1894 and resown at the rate of 40 pounds seed per acre. Crop produced in 1894, first year, from seed, was 1967 pounds per acre. For irrigation of this plat, see No. 2 in Table XV, on Duty of Water, Page 80.

TABLE III.—*Acre Plat 18. Alfalfa at Laramie.*
Area, 0.96 acre.

Year	Fisrt Crop		Second Crop		Total Yield per Acre
	Date Harvested	Yield per Acre	Date Harvested	Yield per Acre	
		lbs.		*lbs.*	*lbs*
1897	July 16	1513	Sept. 9	2587	4100
1898	July 8	3865	Aug. 31	3182	7047
1899	July 24	2430	Sept. 11	1273	3703
Average yield.	. . . .	2603	. . . .	2347	4950

Plat 18 was planted in spring of 1896 at the rate of 30 pounds of seed per acre. The alfalfa made only a short growth the first season, but was cut in the fall, largely to remove the weeds which had grown with it. As it consisted largely of weeds, the hay was not weighed to obtain the yield.

TABLE IV.—*Acre Plat 27. Alfalfa at Laramie.*
Area, 0.5 acre.

Year.	First Crop		Second Crop		Total Yield per Acre
	Date Harvested	Yield per Acre	Date . Harvested	Yield per Acre	
		lbs.		*lbs.*	*lbs.*
1898	July 18	4848	Sept. 8	2985	7833
1899	July 24	3502	Sept. 11	2704	6206
Average yield	. . . . . .	4175	. . . . . .	2844	7019

Plat 27 was planted in 1897 at the rate of 18 pounds seed per acre, with nurse crop of oats. On May 12, 1898, a few thin spots were resown.

TABLE V.—*East Field. Alfalfa at Laramie.*
Area, 3.87 acres.

Year	First Crop		Second Crop		Total Yield per Acre
	Date Harvested	Yield per Acre	Date Harvested	Yield per Acre	
		lbs.		*lbs.*	*lbs.*
1898	July 15-16	289*	Sept. 9	1132	. . . . . .
1899	July 19	3005	Sept. 13	2314	5319

*About one-fourth of the field cut. The rest was from the same season's planting and too small to harvest. This yield is based on entire area of field sown.

The east field was planted in 1897 at the rate of 20.6 pounds of seed per acre. It was sown with nurse crop of oats. Only a part of it grew, and nearly all of the plat was resown in 1898, using at the rate of 20 pounds of seed per acre.

Acre Plat 16.—Alfalfa at Laramie—Turkestan and common form. For report see Table XIII, Page 72.

Acre Plat 15.—Alfalfa at Laramie, sown with and without nurse crop. For report of yields, see Table I, Page 58.

Acre Plat 2.—Alfalfa at Laramie—On alkali ground. For report of yields, see Table XIV, Page 75.

Acre Plat 17.—Alfalfa at Laramie. North part of plat, area 0.70 acre, planted June 15, 1899, at rate of 20 pounds seed per acre, without nurse crop; was cut Sept. 11 and yielded at the rate of 1187 pounds hay per acre. The plants did not make a large growth, but contained some volunteer grain and an occasional plant of old alfalfa, which increased the yield somewhat.

Acre Plat 17.—South part of plat, area 0.25 acre, was planted May 12, 1899 at rate of 20 pounds seed per acre, with a nurse crop of oats. The oats were harvested Aug. 18, after which the alfalfa grew from one to two inches higher than the oat stubble. A good stand of alfalfa was secured on both parts of the plat.

Acre Plat 33.—Alfalfa at Laramie. Area, 0.46 acre. Planted in spring of 1899 by drilling with timothy on stubble ground. The timothy failed to grow. The alfalfa made good growth for the first season. It was cut on Sept. 11 and yielded at the rate of 1766 pounds per acre.

Alfalfa on new sod land, Laramie.—Area, 5.4 acres. Planted in spring of 1899 at the rate of 18 pounds seed per acre with 38 pounds oats per acre. A good stand of alfalfa was secured, but it did not make large growth.

ALFALFA CROPS AT ALTITUDES BELOW 6,000 FEET.—We have a few records of alfalfa yields at Lander, Sheridan and Wheatland, where sub-station farms were located. In 1895 I examined the alfalfa at Sundance, which has been planted since the experiment farm was established in 1891. The plants were small, weak and thinly scattered, having more the appearance of the first year's growth than of having been established four or five years. The Sundance farm depends on the rainfall, which ranges from 17 to 20 inches per year. It is doubtful if alfalfa will succeed in that region.

The following tables give the results at Lander of which we have reports. The Lander farm is located at an altitude of about 5,500 feet.

TABLE VI.—*Acre Plat 45. Alfalfa at Lander.*
Planted in 1891.

Year.	First Crop		Second Crop		Total Yield per Acre
	Date Harvested	Yield per Acre	Date Harvested	Yield per Acre	
		lbs.		*lbs.*	*lbs.*
1892	Aug. 8	. . . . . .	Oct. 5	. . . . . .	8000
1893	July 17	3000	Sept. 13	4000	7000
1894	Oct. 1	Cut for seed,	yield 312 lbs	seed per acre	
1895	Sept. 28*	Cut for seed,	yield 240 lbs	seed per acre	

*The plat was accidentally irrigated on August 20, which caused a second growth of seed that did not ripen and reduced the yield.

TABLE VII.—*Acre Plat 8. Alfalfa at Lander*
Planted May 15, 1893.

Year	First Crop		Second Crop		Total Yield per Acre
	Date Harvested	Yield per Acre	Date Harvested	Yield per Acre	
		lbs.		*lbs.*	*lbs.*
1893	Sept. 12	1000	. . . . . .	. . . . . .	. . . . . .
1894	. . . . . .	3500	. . . . . .	1500*	. . . . . .
1885	July 5	5000	Sept. 11	3000	8000

*This crop was badly injured by the Utah crickets, which devoured everything in their path.

SHERIDAN.—The Sheridan farm is located at an altitude of about 4,000 feet. The soil is clay underlaid with hard pan, but alfalfa makes remarkable growth and yields.

No doubt it will do better on other farms near Sheridan where the soil is deeper. We have but few reports of crops raised. In 1896, acre plat 5 was planted to alfalfa. It was cut August 1 to kill the weeds, and Sept. 10 the first year it yielded 1200 pounds per acre. In 1897, on June 21, 3700 pounds of hay per acre were obtained, but no other reports were made on the plat. The following table gives the results on the only other field reported.

TABLE VIII.—*Acre Plat 30. Alfalfa at Sheridan.*
Planted May 24, 1894.

Year	First Crop		Second Crop		Third Crop		Total Yield
	Date	Yield	Date	Yield	Date	Yield	
		lbs.		*lbs.*		*lbs.*	*lbs*
1894.	Aug. 2*	. . . . .	Sept. 24	1500	. . . . . .	. . . . . .	. . .
1895.	June 26	. . . . .	Aug. 21	. . . . . .	. . . . . .	. . . . . .	[illegible]
1896.	June 25	6800	Aug. 10	6000	Sept. 28	4000	16800
1897.	June 20	6430	Aug. 11	6200	Oct. 3	1800	14430

*Cut to kill the weeds.

WHEATLAND.—The sub-station farm at Wheatland was located at an altitude of about 4,700 feet. The soil is a deep sandy loam and the season is long. The alfalfa is usually cut three times and large yields are secured. Several fields of alfalfa were grown to improve the land for other crops, usually being plowed under when green, the fall of the year it was planted. In 1895, Plat 1 was sown with alfalfa for the purpose of plowing under as a green manure. It made such rapid growth that it was harvested on July 22 and yielded 2,400 pounds hay per acre. The second crop was plowed under. The same year, 1895, Plat 2 was treated in the same manner. The first crop yielded 2,540 pounds per acre. Plats 7, 8 and 9 were treated the same and yielded at the first cutting 2,100 pounds, 2,600 pounds and 2,450 pounds per acre, respectively. The following tables give the results with fields on which the alfalfa was allowed to grow more than one year:

TABLE IX.—*Acre Plat 19. Alfalfa at Wheatland.*

Planted June, 1891.

Year	First Crop		Second Crop		Third Crop		Total Yield per Acre
	Date	Yield	Date	Yield	Date	Yield	
		lbs		*lbs.*		*lbs.*	*lbs.*
1892.	July 6	6500	Aug. 3	5400	Sept. 26	3850	15750
1893.	July 5	6680	Aug. 9	4872	Sept. 16	4200	15752
1894.	June 23	8000	Aug. 6	7000	Sept. 17	4352	19352
1895.	Cut for	seed, yield	181 pounds	seed per	acre.		
1896.	Left for	seed	but was	injured by	hail June	21st.	
Average, first 3 yrs		7060		5757		4134	16951

TABLE X —*Acre Plat 12. Alfalfa at Wheatland.*

Planted in 1894.

Year	First Crop		Second Crop		Third Crop		Total Yield per Acre
	Date	Yield	Date	Yield	Date	Yield	
		lbs.		*lbs.*		*lbs.*	*lbs.*
1895	June 28	7832	Aug. 16	7620	Sept. 18	4950	20402
1896	June 18	5880	Aug. 3	4500	*	. . . . .	10380

*Owing to shortage of water for irrigation in 1896, only two crops were obtained.

TABLE XI.—*Acre Plat 17. Alfalfa at Wheatland.*

Planted in 1894.

Year	First Crop		Second Crop		Third Crop		Total Yield per Acre
	Date	Yield	Date	Yield	Date	Yield	
		lbs.		*lbs.*		*lbs.*	*lbs.*
1895	June 28	4312	Aug. 16	4500	Sept. 18	2540	11352
1896	June 20	6720	July 29	4750	*	. . . . .	11470

*No third crop reported, probably for same reason as that given under Acre Plat 12.

TABLE XII.—*Acre Plat 26. Alfalfa at Wheatland.*
Planted in 1892. (?)

Year	First Crop		Second Crop		Third Crop		Total Yield per Acre
	Date	Yield	Date	Yield	Date	Yield	
		lbs.		*lbs.*		*lbs.*	*lbs.*
1893	July 5	3422	Aug 9	4112	Sept. 16	3000	10534
1894	*	. . . . . .	Left for	seed. Pro	duced 122	lbs seed	per acre
1895	June 28	5214	Left for	seed.**	. . . . .	. . . . .	. . . .

*First crop destroyed by army worms. (Species not known.)

**After first cutting was left for seed. At time of frost, on Sept. 21, about one-half the seed was mature. The crop was not harvested.

TURKESTAN ALFALFA.

(*Medicago sativa Turkestanica.*)

The seed* of this new variety of alfalfa was imported by the U. S. Department of Agriculture and a small amount was sent to this Station for trial in the spring of 1895 A small plat 12x99 feet was planted with it, by sowing broadcast, the first week in June. Two pounds of seed were used on the plat. It came up June 10th, making a thick stand, and made a growth of about four inches the first season. Little attention was given the crop in 1896 and the yield of the single cutting made was very small. The crop looked promising in 1897 and was left to grow as long as possible with the hope that it would ripen seed. It was planted so thickly, however, that the seed failed to ripen.**

It was not cut till after frost had stopped its growth and the yield obtained was only ordinary for a single cutting. If it had been cut twice or earlier in the season the yield would undoubtedly have been much better. Some botanists have claimed that the Turkestan alfalfa differs from the species in having more hairy leaves and making smaller growth, but we have been unable to detect any botanical difference whatever. A stem of each variety was shown a Botanist who thought he knew the difference and he was unable to say which was common alfalfa and which the new variety. Its growth appeared the same to us and we gave it little attention until the severe winter of 1898-99 put it to the test. On all parts of the farm plats of alfalfa showed more or less winter killing, but to all appearances not a single plant of the Turkestan variety had been killed. We find that it has also shown its hardiness in other places and we no longer doubt its superior cropping qualities. Not only does it seem to be hardier but under our conditions it has produced larger yields than the old variety, when planted side by side, and given the same treatment, in time and amount of irrigation and method of handling. Its difference from the common form seems to be in constitution and hardiness or from favorable results due to change of seed. No doubt both of these conditions have their influence on its success in this country and gives the variety greater value, especially for our high altitude.

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*Since the Secretary of Agriculture reported our success with Turkestan alfalfa we are receiving many inquiries for the seed from farmers all over the United States. The seed can not be obtained in this country, as no one has yet raised it for market. Prof. Jared G. Smith of the Division of Botany, in the U. S. Department of Agriculture, has told me that the Department is making an attempt to import more of this seed for distribution in small amounts.

**Mr. A. H. Danielson, an assistant in this department, who was then an agricultural student in the University, was given a small handful of the seed which was furnished us by the Department. He took it home and threw it in the back yard. It came up and has since ripened a little seed, which he has kindly offered us. With it we hope to make a thin planting which will produce more of the seed for future use.

Our results with Turkestan alfalfa are given in Table 13, in which we have also compared the crops produced from a plat of the ordinary form which was planted near it for comparison. Averaging the results for the last two seasons, 1898 and 1899, when they have been cut for hay and cured alike, shows the superior cropping qualities of the new variety, which produced over three-fourths of a ton more hay per acre. For amounts of water used on these plats in irrigating in 1899, see No. 10 in Table XV, Page 80, on Duty of Water.

TABLE XIII.—*Acre Plat 16. Turkestan Alfalfa and Common Form. Laramie.*

Year	Turkestan Alfalfa. Planted 1895.					Common Alfalfa. Planted 1896.				
	Date of First Cutting	Date of Second Cutting	Yield First Crop per acre	Yield Second Crop per acre	Total Yield per acre	Date of First Cutting	Date of Second Cutting	Yield First Crop per acre	Yield Second Crop per acre	Total Yield per acre
			lbs.	*lbs.*	*lbs.*			*lbs.*	*lbs.*	*lbs.*
1896	Sept. 21	. . . .	912	. . .	. . .	. . . .	. . . .	. . .	. . .	. . .
1897	Sept. 9	. . . .	3302*	. . .	. . .	Aug. 6.	Sept 9	3240	2340	5580
1898	Aug. 3	Sept. 15	6446	943	7389	Aug. 3.	Sept. 15	5580	900	6480
1899	July 20	Sept. 11	4717	3145	7862	July 20	Sept. 11	3060	2520	5580
Average last two years	. . . .	. . . .	5581	2044	7625	. . . .	. . . .	4320	1710	6030

*Cut at time of frost.

Alfalfa Common variety, showing Height of Second Crop. Laramie, 1899.
Wyoming Experiment Station.

Turkestan Alfalfa. Second Crop. Laramie, 1899. Wyoming Experiment Station.

UNIV. OF MICH.

WINTER KILLING OF ALFALFA.

Only general statements will be made here regarding the killing of alfalfa plants during the winter. So far as we have observed, the trouble is no more apt to occur at high altitudes on the Laramie Plains than it is at lower altitudes in other parts of the state. The trouble reported from Wheatland and other localities has been more extensive than any we have experienced at Laramie.

Little is positively known of the cause of winter killing of alfalfa. Apparently it is due to hard freezing when the ground is very wet. If water is run on the plants just before hard freezing there is danger that they may be killed. In places where heavy snow fall melts during the day, and the surface of the soil becomes thawed out, so the water runs into the soil around the crown of the plant and freezes, the alfalfa crown will die and will be found in the spring in a soft, mushy or decayed condition. Ice may form over the alfalfa, or snow cover it all winter without injury to it, but if ice does no damage it is probably due to the ground being frozen before the ice is formed over the surface and the crowns of the plants, which are usually below the soil surface, do not come directly into contact with freezing water. In the opinion of the writer winter killing is generally due to free water freezing around the crown of the plant. Whether the freezing of the water in the plants ruptures the cells or not has not been determined. During dry, open winters little or no alfalfa which has been growing long enough to become well established is lost unless it be in low, wet places. As shown elsewhere in this bulletin, the Turkestan alfalfa seems better able to live under adverse conditions than the form commonly grown, but with proper precaution in locating the alfalfa field and care in handling it, winter killing is not a serious trouble with us. The spring of 1899, after the unusually hard winter, was the only time we have observed any extensive winter killing on the Experiment Farm. The writer's opinion in regard to its cause is the result of studying these instances along with observations in other places.

ALFALFA AND ALKALI SOILS.

Alfalfa is one of the most valuable plants to sow on low parts of the farm which may become useless through the rise of alkali from below, at least if this land has such drainage that the free ground water does not stand nearer than two or three feet from the surface. Alfalfa stands the white alkali comparatively well, shades the ground, which prevents rapid evaporation from the soil surface, and sends its roots deep into the lower soil to feed. We have reported on the germination and growth of alfalfa in several experiments which indicate its usefulness for such soils.* It is true, however, that in places which accumulate large amounts of alkali the free soil water usually comes near the surface for a part of the year at least. Whether the soil water contains alkali salts in solution or not, if it stands near the surface alfalfa will soon die, and much less salt evidently has deleterious effect in such places.

In 1897 we planted alfalfa on an acre of land which was near that already destroyed for ordinary crops by the rise of salts to the surface. A part of the land had failed to grow a crop of oats planted with the alfalfa as a nurse crop, and where the oats had failed to grow the alfalfa had a sickly appearance. A good stand of alfalfa was secured. In 1898 the acre yielded two and three-fourths tons of hay. On the lower part of the plat the alfalfa began to die that year and nearly one-half the total area has become unproductive. The yield of hay in 1899 fell to a little over one and one-half tons. The following table gives the crops produced on this land:

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*See Bulletins Nos. 29 and 39, and Ninth Annual Report, Wyoming Experiment Station.

TABLE XIV.—*Acre Plat 2. Alfalfa on Alkali Land. Laramie.*
Area .96 acre.

Year	First Crop		Second Crop		Total Yield per Acre
	Date Harvested	Yield per Acre	Date Harvested	Yield per Acre	
		lbs.		*lbs.*	*lbs.*
1898	July 14	3156	Sept. 8	2356	5512
1899	July 20	1853	Sept. 12	1335	3188
Average yield for two years .	. . . . . .	2504	. . . . . .	1845	4350

Acre plat 2 was planted in the spring of 1897 at rate of 16 pounds seed per acre, with a nurse crop of oats. On May 11, 1898, the entire plat was resown. From one-third to one-half the entire plat has become unproductive through the killing of the plants by alkali, but above yields are taken for the area of the land sown. For irrigation of this plat in 1899, see No. 9, in Table XV, Duty of Water, on Page 80.

Professor Slosson has kindly analyzed four samples of soil taken from this plat to show the strength of alkali which has killed the alfalfa and the strength of salts in the part of the plat on which the plants are still in a thrifty condition.

The following amount of salts were found in the samples taken:

	Percent.	Percent of Sodium Chloride.
Alfalfa Killed.		
Total salts in first six inches of soil.	0.620	0.029
Total salts in soil from six inches to one foot deep . .	0.792	0.053
Alfalfa Thrifty.		
Total salts in first six inches of soil.	0.034	0.000
Total salts in soil from six inches to one foot deep . .	0.270	0.003

The Sodium Chloride is reported separately, as it is more injurious than the sulphates, which probably make up about three-fourths of the total salts.* The result probably corresponds closely to the estimate made in Bulletin No. 39 of this station,** in which we expressed the belief that alfalfa would grow in the presence of as much as one per cent of our ordinary white alkali (Sulphate of Soda and Magnesia) in two inches of surface soil, providing the water level is not nearer the surface than two or three feet. We suspect the water level is dangerously near the surface in the above plat during a portion of the irrigating season, and has had its influence in destroying the plants which have died.

It is very doubtful if alfalfa will grow on any land upon which there is a white incrustation of salts during any part of the year, unless the drainage is such that the salts may be washed out by flooding with irrigation water. Soil which becomes incrusted with salts is too strong with alkali for any plants except the most resistent species, and our experience indicates that it should never be selected for the production of an alfalfa meadow. In many places on the Laramie Plains there are soils which are either too wet or contain too much alkali for alfalfa and it is hoped calling attention to the matter here will prevent many farmers from the loss of labor and seed by attempting to grow it in such places.

IRRIGATION OF ALFALFA.

Although alfalfa is so hardy and will live through long periods of drouth it will not produce hay unless irrigated. It is of vital importance to apply water at the right time and conduct the irrigation in the right way. Flooding as the native meadows are flooded for long periods of time is much more quickly fatal to alfalfa than it is to our best native grasses. It will not do to turn the water on and look at it once a week to see that it is still running. Alfalfa soon dies if its feet are kept wet, and it needs long breathing spells and warm growing weather. Where the irrigating water is cold it produces a chilling effect, and the irrigation should be done quickly and the water turned off as soon as the ground has become thoroughly wet. The best time to irrigate alfalfa is immediately after the hay has been removed. Some irrigate just before the hay is cut, but our observations indicate that much better results are obtained by irrigating after cutting. If the weather is very dry, light irrigations may be needed between the cuttings. We believe in irrigating in the fall, some time after the last cutting has been made, to keep the soil from becoming too dry during the winter. It should not be done so late, however, that the ground is apt to freeze hard while very wet, as this seems to be the principal cause of winter killing. Too much water is fatal either in the summer or winter. On the Experiment Farm one season we irrigated one-half of a field of alfalfa as late as October, leaving the other half without water. The part irrigated started earlier the next spring and up to the time of the first cutting the dividing line between that which had not been irrigated and that which was watered late in the fall was distinctly visible, as the hay grew two or three inches higher on the fall irrigated portion.

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*For composition of alkali from this portion of our farm according to previous analyses, see Bulletin No. 29, page 223.

**Wyoming Station Bulletin No. 39, page 47.

DUTY OF WATER ON ALFALFA.—By duty of water we mean the amount which is used on the land. Alfalfa is a perennial plant which occupies the land all the time. Its growing season is long and that it requires a proportionally large amount of water would be expected. Table XV gives the results of fifteen measurements of water on alfalfa made by the Experiment Station. All these measurements were made on the Experiment Station Farm at Laramie, except No. 1, which was made at Wheatland in 1893. (For record of the cropping on this plat, see Table IX, Page 69.) In this table the duty is expressed in the number of cubic feet of water used on each acre of land; in the depth to which the water used would cover the land, or as the records are reduced to the acre standard this depth represents the number of acre feet used for each acre;* in the number of acres which one cubic foot per second continuous flow would irrigate if used at the same rate as on these crops and allowed to run four months or 123 days, and also if allowed to run only 95 days. Ninety-five days very nearly represents the irrigating season for alfalfa at Laramie, though four months is nearer the length of the growing season.

As the amount of rainfall has such an important bearing on the amount of water needed in irrigation, we have added two columns, one of which shows the depth to which the water used in irrigation and that supplied as rain during the growing months of May, June, July, August and September covered the land, and the other shows the total amount of water coming to the land during the entire year by both irrigation and rainfall. The table shows that we have not used very large amounts of water in the production of alfalfa. Our measurements of water used on native hay show that only about one-half as much water was used on alfalfa as on the native hay, and undoubtedly the difference between the two kinds of hay will be found to be as great as this. An average of the fourteen measurements which have been made at Laramie shows the depth of water applied to alfalfa to be 2.22 feet. An average of six measurements on oats, wheat and barley made before 1899 shows 2.74 acre feet applied to each acre of those crops. The only class of plants on which less water has been used than on the alfalfa have been root crops. An average of seven measurements of the irrigation water used on potatoes, turnips, and sugar beets at Laramie before 1899 shows the depth applied to be only 0.98 feet.

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*An acre foot is the amount required to cover one acre one foot deep, or 43,560 cubic feet.

The following table gives the number of times each field of alfalfa was irrigated, the date of each irrigation and the amount of water applied each time in cubic feet per acre, and the depth to which it would cover the land.

TABLE XV.—*Duty of Water on Alfalfa.*

No.	Year	Area	Date Planted	No. of Irrigations	Water received by Irrigation per Acre		Depth of Water Supplied by Irrigation and Rainfall in yr.	Depth of Water received by Irrigation and Rainfall in growing season*	Duty of 1 sec. ft. for season of 4 months	Duty of 1 sec. ft. for season of 95 days	Yield per Acre	Remarks.
					Quantity	Depth over surface						
		acres			*cu. ft.*	*ft.*	*ft.*	*ft.*	*acres*	*acres*	*lbs.*	
1	1893	1.	1891	6	113,184	2.60	3.13	2.71	93.8	72.6	15752	At Wheatland. Three crops.
2	1896	.52	1894	2	47,356	1.08	1.98	1.69	224.5	173.3	4664	Laramie. Two crops.
3	1898	1.	1898	4	129,388	2.97	3.61	3.35	82.0	63.4	2220	Laramie. First year.
4	1898	3.9	1894	5	113,101	2.60	3.24	2.98	94.0	72.6	8668	Laramie. Two crops.
5	1899	3.87	1897-98	4	135,365	3.11	4.02	3.53	78.5	60.7	5319	Laramie. [nurse crop.
6	"	.95	1897	3	84,663	2.14	3.05	2.56	125.5	97.0	5510	Laramie. Average yield with and without
7	"	.50	1897	3	103,680	2.38	3.29	2.80	102.5	79.2	6906	Laramie. Sown with Oats in '97, two crops.
8	"	.70	1899	2	100,190	2.30	3.21	2.72	106.1	82.1	1187	Laramie. First year.
9	"	.25	1897	1	42,689	0.98	1.89	1.40	249.0	192.3	3188	Laramie. One-half of plat killed by alkali.
10	"	.03	1895	3	78,219	1.82	2.73	2.24	135.9	104.9	7862	Laramie. Turkestan Alfalfa.
11	"	.98	. . . .	3	103,900	2.38	3.29	2.80	102.3	79.0	. . .	Laramie. With Oats.
12	"	.25	1899	3	104,226	2.39	3.30	2.81	102.0	78.8	. . .	Laramie. First year, with Oats.
13	"	.96	. . . .	2	70,132	1.61	2.52	2.03	161.6	117.0	. . .	Laramie. With Oats.
14	"	.46	1899	3	134,165	3.08	3.99	3.50	79.2	61.2	1766	Laramie. First year, with Timothy.
15	"	5.4	1899	2	98,881	2.27	3.18	2.69	107.5	83.0	. . .	Laramie. First year, on sod with Oats.

*Growing season five months, May, June, July, August and September.

ENEMIES OF ALFALFA.

As yet few insect pests of alfalfa have been observed in the state, and no cases of rust or other fungous diseases have come to notice. At Lander one crop of hay was destroyed by the Utah cricket which invaded the farm in great numbers in 1894. At Wheatland one crop was destroyed by caterpillars which the Superintendent reported as army worms. The caterpillar of a small yellow butterfly, closely related to the cabbage worm, has also been reported on the alfalfa at Wheatland, but not numerous enough to do appreciable damage. By far the most serious enemy of alfalfa in this state is dodder. At Sheridan the alfalfa makes strong enough growth so the dodder does not kill it, but the hay is seriously injured by it. The following report on dodder made by the writer in Bulletin No. 16 of this station is here repeated because of its importance and relation to the subject.

"DODDER.—Alfalfa is sometimes affected by rust and insect pests, but as yet its greatest foe in this state is dodder, (*Cuscuta*), there being several species indigenous to this region. Dodder has been quite destructive on the Laramie, Saratoga and Sheridan Experiment Farms. It is a small annual parasitic plant with yellow or reddish-yellow twining stems, which wind themselves around the stems of alfalfa, clover or similar plants, near the ground, taking its nourishment from its host. It has small colorless scale-like leaves and produces clusters of ten or more flowers, each of which contains four small grayish seeds which are about half the size of alfalfa seed. These fall to the ground where they remain until the next season when they germinate. The young dodder plant cannot live long in the ground and unless it finds a host plant, soon dies. Where it is abundant the plants upon which it feeds assume an unhealthy appearance and finally die.

"Dodder can be killed by cutting the hay before the dodder blossoms and burning it, or by plowing the crop under and cultivating the land for a year or two in corn, potatoes or other plants which have stems so large that dodder does not live upon them. Great care should be taken in purchasing alfalfa seed to get that which is pure. If our farmers would raise their own seed it could be kept free from dodder and other weeds and would also have the advantage of being acclimated."

APPENDIX.

OTHER TRIALS OF ALFALFA ON THE LARAMIE PLAINS

In addition to the experiments on the Station farm we give the results which have been obtained by our farmers on the Laramie Plains so far as we could obtain information of trials that have been made. A number of first attempts to grow alfalfa have failed, but these have not been left out on that account. Negative results are often as valuable as positive ones. In experimental work the lesson taught by a failure may be as important as that of a success. If the reason for the failure can be pointed out, more may be learned from a knowledge of it than will be learned if the results we strive to obtain are reached without difficulty. In the light of nine years investigation by the Station, we think the results obtained on our farms are encouraging. Heretofore writers on alfalfa have placed its altitude limit at seven thousand feet, but enough has been done by our farmers to demonstrate that it will succeed above that altitude if the conditions of soil and water are favorable. Alfalfa has succeeded so universally at low altitudes in the arid region that there is no necessity of our giving accounts of it there. It succeeds under such wide range of treatment, below six thousand feet above the sea, that there is no longer any question of its value as a fodder plant. We have an account of alfalfa having been planted on the Laramie Plains nearly twenty years ago. Mr. Ryan has told me that about twenty years ago Mr. McCarthy planted a small field of alfalfa on the red land just north of Laramie and that it produced two good crops of hay the second year. It was afterwards neglected and destroyed by stock, drouth, and perhaps the rise of alkali from the land becoming wet through water supplied by an artesian well. We have learned that some plants of alfalfa are still showing on the old Jones and Norton ranch, where it was planted seven or eight years ago and left on the open plains where stock have pastured over it continously. We have already told of the failure with alfalfa by a ranchman who spent large sums in trying to grow it about ten years ago. We have also been told that Mr. J. W. Collins tried it with little or no success. Mr. Oliver Mansfield has tried alfalfa several seasons on his ranch located about twenty miles west of Laramie on the Big Laramie River, but has not obtained a hay crop. It is planted on the river bottom on sandy land. which is located about one-half mile from the river and it is stated that ground water does not come near the surface. However, the plants have turned yellow and been winter killed except on a small spot of clay ground where they have succeeded better. Mr. Mansfield is not satisfied that alfalfa will not succeed and is planning to give it further trial.

Mr. S. A. Crawford sowed one hundred pounds of alfalfa seed two years ago and fifty pounds last year. He secured a good stand but the plants did not make large growth. Stock have been allowed to pasture the young alfalfa. He has confidence it will succeed and will put in an additional amount this spring.

Mr. C. H. Jones has given an account of some alfalfa planted a few years ago on his ranch. It was sown in the pasture where stock have had access to it since, and where no attention has been given to its irrigation and care. The stand was somewhat scattering, but plants have made thrifty growth. Mr. Jones states that he believes alfalfa would be a valuable hay crop for the plains where properly planted and cared for.

Mr. Trabing, who is a pioneer in agricultural investigations on the Laramie Plains, has grown alfalfa for about six years on his farm at Laramie. He states that two good crops have been harvested every year and that much more hay is secured than native grass will produce. He says that the troublesome foxtail all disappears where alfalfa is growing. The alfalfa will freeze out where the ground freezes hard when it is very wet, but where kept dry in the winter no difficulty of the kind has been experienced. Mr. Trabing has demonstrated the success of alfalfa and will plant a larger area to it the coming season.

Mr. M. A. Crout is very enthusiastic over the success of alfalfa on the Pryor ranch, located sixteen miles west of Laramie, under the Pioneer Canal. About six acres of alfalfa were drilled in by Mr. Pryor in the spring of 1898. Mr. Crout, who now occupies the ranch, says he cut the alfalfa twice last season and although it was not irrigated for the second crop a good quantity of hay was obtained. The yield would have been greatly increased if it had been irrigated, but Mr. Crout thinks he makes a conservative estimate when he says that he obtained as much hay as could be produced on four times the amount of land in native grass. He has fed the hay to his cattle during the winter and they have fattened on it. He says further that it is the best hay for all purposes he has ever used. Fed to horses it gave the most satisfactory results and "if a horse is poor and hidebound he can be put into good condition in a short time by feeding alfalfa." The hay was nicely cured and has produced no bloating or other trouble.

The following letter from Mr. Webber shows his faith in alfalfa as a hay crop. He has fed the hay to his milch cows with the best results.

LETTER FROM MR. C. W. WEBBER.

Dear Sir: As there has been quite a difference of opinion in regard to the success of growing alfalfa in Albany County, I will give my experience.

I believe that with proper care to get it started, alfalfa is a successful crop in this part of the state. In 1897 I sowed one acre broadcast after drilling oats for a nurse crop and secured a very good stand. In 1898 I drilled in four acres more, using about 25 pounds of seed to the acre. This seed was planted without a nurse crop. It was watered twice before cutting and turned off about a ton of hay to the acre. The first acre which was sown the year before was cut twice and yielded about three tons in 1899. I drilled about twelve acres more to alfalfa last season. It was drilled as nearly as possible in the same manner as the above four acres. This piece was also watered twice before cutting, with the exception of about two acres which had water once. The land which was only irrigated once was covered with a good stand of plants but the ground became so baked that they did not grow very high. This piece of twelve acres was cut once and yielded about three-fourths of a ton per acre. The four acres drilled the year before was cut twice and yielded three tons to the acre. The first acre that was sown in 1897 winter killed during the hard winter of 1898 and 1899, but clover and alfalfa winter killed all over the East and in Colorado, so the difficulty was not peculiar alone to our conditions of soil or climate. This acre was replowed and alfalfa again drilled in, and it made a vigorous growth last season. The ground was all watered after the last cutting and the alfalfa made a good growth before freezing. I would advise any one contemplating sowing alfalfa to drill it in lightly on a compact seed bed on ground that had been irrigated one or more seasons before, and I have no doubt of their success.

Yours Truly,
C. W. WEBBER.

Mr. Webber's place is about a mile west of Laramie, on the open plains. Some of the land on which he planted alfalfa had been manured and the plants made strong, thrifty growth. Measurements of water made on his place last year showed the amount of water used to irrigate 80 acres to be 153.8 acre feet, or enough to cover the land 1.92 feet deep. We do not know how much of this was used on alfalfa, but it was probably only a proportional amount.

Mr. Thomas Bird, who lives in the Centennial Valley, about thirty-five miles west of Laramie, has written the following interesting account of attempts to grow alfalfa on his ranch:

LETTER FROM THOS. BIRD, CENTENNIAL, WYOMING.

Dear Sir: Some three years ago I sowed alfalfa on about four acres of ground that had been broken two years before. The soil is mostly gravel, but portions are partially clay and all was well tilled. The alfalfa came up the first year and made what appeared to be a good stand. The growth was not large enough to cut the hay the first year. The second year the plants stooled out fairly well and we cut it but did not secure what I would call a good crop, probably one-half ton per acre and only one cutting. The third year, which was last season, nearly all the plants had been killed by excessive cold winter or some other cause, so it will be plowed up the coming spring and other use made of the land. This piece of ground is 300 feet from the river at the farthest point, not more than five feet higher than extreme low water mark and two and one-half feet higher than high water mark. This land has never been irrigated but you will bear in mind that we get more rain at the base of the mountains than falls in Laramie.

In the spring of 1898 we sowed one acre of poor gravelly land not far from above piece to alfalfa. It came up much as did the first sown, but did not get large enough to cut the first year. The second year (last season) we irrigated this piece and cut the hay. We did not get a large crop, but better than we secured the second year from the four acre piece described above. As it stood the winter of one year ago, which was the first after planting the seed, I think that by irrigating it as we should it will probably do something.

Some eleven years ago we sowed about one-fourth acre alfalfa on high ground which is probably six feet above low water mark in the river. This has not been irrigated at any time but there are ten or fifteen stalks which are there still. These have made fine growth and blossomed each season since the second year. Digging around some of these roots I find them at two or three inches from the top of the ground to be from one to one and three-fourths inches in diameter. The rest of the plants died the second or third year after being sown.

This concludes our experience, and while it looks discouraging our opinion is that had we irrigated our alfalfa as it should have been the results would have been different. With proper irrigation I think that at least one good cutting can be made. We think the seed should not be spared in sowing, and when we plant more, as is our intention, 20 or 25 pounds of seed per acre will be used. I have written at some length in order to explain fully what we have done, as you requested. I hope the information may be of value and that it will not deter others from giving alfalfa a fair trial. We are fully convinced of the importance of giving proper attention to the irrigation of alfalfa, at least during the first two seasons of its growth, and with this attention we believe it can be made at least a partial success even at this high altitude.

Yours very truly,
THOS. BIRD.

Mr. Bird's place is in the upper part of the Centennial Valley at an altitude of about 8,000 feet. Undoubtedly much more rain and snow falls in that locality than lower down on the open plains. In my opinion those who have read this bulletin will find a study of Mr. Bird's letter anything but discouraging, as he indicates. The fact that plants have lived for eleven years without irrigation or care at such an altitude certainly shows their hardiness. Alfalfa can not be expected to succeed any place in our state without irrigation. With proper attention it will probably succeed well enough in the Centennial Valley to produce as much or more hay per acre than will native hay.

SUMMARY.

Alfalfa succeeds in all parts of Wyoming under 8,000 feet altitude where it can be irrigated and makes more fodder to the acre than any other hay plant yet introduced.

Under proper care and right treatment, raising alfalfa may be made profitable up to nearly or quite 8,000 feet altitude. It does not require special culture where grown below 6,000 feet altitude.

Between 7,000 and 8,000 feet above the sea, alfalfa can generally be cut twice, though only the first cutting may produce a full crop. Where cut twice in the season the yield is from two and one-half to four tons per acre. Below 5,000 feet altitude it is cut three and four times each season and yields from four to ten tons of cured hay per acre.

At high altitudes alfalfa requires careful treatment to secure a good stand and become well established. Heavy seeding and planting with the press drill are recommended.

Two seasons are required to put the alfalfa into good producing condition on the Laramie Plains.

Alfalfa grows better and produces larger crops for two or three years after planting if sown alone instead of with oats or other nurse crop. This may be due to securing better stand. However, it may be planted with grain and when sown with nurse crop the seeding of grain should be light, and early, small strawed varieties used.

Turkestan alfalfa has stood the winters better and produced heavier crops than the common form at Laramie.

The principal cause of winter killing seems to be the freezing of water around the crowns of the plants.

Alfalfa will not grow on wet land where the ground water stands as near the surface as one or two feet.

No one should expect to obtain good hay crops of alfalfa without regularly irrigating it. It requires occasional irrigations through the growing season, and fall irrigation is beneficial.

The average amount of irrigation water which has been used on alfalfa at Laramie would cover the land 2.22 feet deep. This is a little less than the amount used to irrigate grain and much less than is used on native hay.

Alfalfa grows better where there is some alkali salt in the soil but will not stand more than one per cent of our common white alkali in the first six inches of soil. It should not be planted where there is enough alkali to form white incrustations on the surface of the soil during any part of the year.

The principal enemy of alfalfa in Wyoming is dodder, which may be prevented by using clean seed.

Alfalfa is not only a valuable hay crop but improves the land by taking nitrogen from the air and fixing it in the soil. It is considered the greatest boon to the west of any plant we cultivate.

(Note.—The next bulletin of the Wyoming Station (No. 44.) will deal with the power of alfalfa to improve the soil for the raising of other crops.)

UNIVERSITY OF WYOMING.

Agricultural College Department.

WYOMING EXPERIMENT STATION,

LARAMIE, WYOMING.

BULLETIN NO. 44.

APRIL, 1900.

ALFALFA AS A FERTILIZER.

BY B. C. BUFFUM.

Bulletins will be sent free upon request. Address: Director Experiment Station, Laramie, Wyo.

Wyoming Agricultural Experiment Station.

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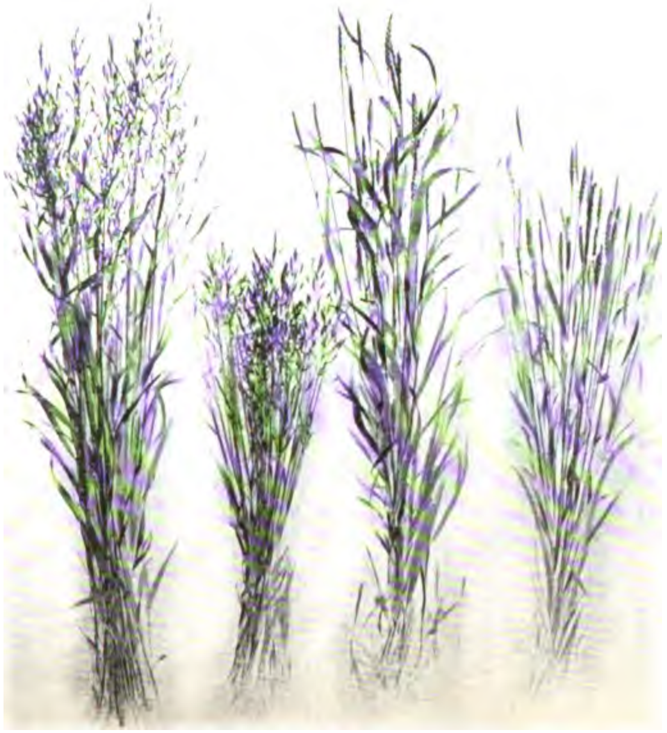

PLATE I.

1.—Oats from Alfalfa land. 2.—Oats from land used for rotation. 3. Wheat from Alfalfa land. 4.—Wheat from land used for rotation

ALFALFA AS A FERTILIZER AND SOIL IMPROVER.

B. C. BUFFUM.

GENERAL CONSIDERATIONS.

How to make the soil highly productive and keep it so is often one of the most difficult problems the farmer has to solve. The soil is a wonderful compound and studies of it have resulted in some of the greatest discoveries in science. The soil upon which we depend for so many of the blessings we enjoy is not merely a dead, inert mass of particles of rocks which have been torn to pieces by the weather, but is a place of great activity and continual movement, teeming in its dark recesses with forms of life which are so small that we can not see them except with a microscope, but of such importance that the world would neither be clothed nor fed if they did not exist.

The higher plants upon which man and animals are dependent, either directly or indirectly, for food and shelter can only grow in soils which are in favorable condition of tilth and moisture and then only when supplied with the kind of food they require. Out of the fourteen or fifteen different elements which plants must have as food, only two or three can be taken from the air by them, and the rest must be supplied by the soil. If the soil does not contain these elements in sufficient amounts and in such combination or soluble condition that plants can absorb and use them, it will not produce crops. Fortunately nearly all the foods required by plants are so abundant that the farmer needs to give them no attention, and only those which are most rare or which are apt to be present in the soil in such small amounts that they soon become exhausted, become of importance to him. Some soils may be deficient in lime (in regions where there is no lime stone or where the lime is so combined that it is of no value to the soil or plant), but as a general rule the only elements which we need to supply the land are potash, phosphoric acid and nitrogen. Of these potash and phosphoric acid are the most abundant. In the arid regions many of our soils contain so much potash that any amount of cropping will not exhaust it. Our common river sand at Laramie contains over 3.5 percent of potash* so that in one acre of it one foot deep there would be approximately 150,000 pounds of potash, more than enough to supply large crops of wheat for a thousand years.

The fine earth on the Laramie farm, after the sand and gravel had been sifted out, contained 0.56 percent of potash**, fully enough to last our wheat crops two hundred years if we do not call on the supply from deeper soil or the coarser particles, which are largely pieces of granite rich in potash. This estimate is only a rough one, but it serves to show the abundance of such foods in our soils.

Phosphoric acid is not so abundant, but our soils contain a sufficient amount as a rule. It is true that these elements are often abundant in the soil and still not available to plants, as they are in combination and insoluble. This is more apt to be the case if the soil is not in good tilth. Since the time of Jethro Tull, nearly 200 years ago, the importance of tillage has been known, though not fully appreciated by many. Tull thought tillage the only thing necessary to make and keep the land productive. This is probably true in the arid region so far as potash is concerned, but tillage does not add new food to the soil except as it favors the multiplication and work of the organisms in the soil which appropriate nitrogen from the air and change that obtained in other ways into forms made use of by plants. Nitrogen is one of the most common elements, as it composes about four-fifths of the air, but as a plant food it is not abundant and is the most expensive fertilizer the farmer has to provide, at least where purchased in commercial form. Plants* can make use of nitrogen only when it is in the form of nitric acid or perhaps ammonia.

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*Analysis made by A. H. Danielson, B. S., March, 1900.

**For analyses of Wyoming soils, see Bulletin No. 6, Wyoming Experiment Station, by Prof. E. E. Slosson. Pages 13 to 26.

The larger part of the nitrogen in the soil is the result of decaying vegetable matter which produces humus. Because of the small amount of vegetation on our arid soils they are usually poor in humus and nitrogen. If they are in good tilth and yet become unproductive it is generally because the nitrogen has become exhausted. It may be added to the soil by applying commercial fertilizers which contain it, as nitrates, raw bone meal or other organic compound or with barnyard manure which contains large amounts of vegetable matter, ammonia and other forms of nitrogen. Among all fertilizers, the first of importance is nitrogen, and the fertilizer which contains the most of it in the form needed by plants is the most valuable. Sir William Crooks, one of the world's foremost scientists, has predicted that wide-spread famine will finally result from the failure of the wheat crops of the world because the nitrogen of the soil is being exhausted and there is such general waste of this element instead of returning it to the land.

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*Plants as here spoken of refers only to the higher plants, those which produce flowers and seeds. The minute organisms in the soil known as bacteria or ferments, which change other forms of nitrogen into nitric acid, are also classed as plants, but in popular usage the word plants does not include them.

RELATION OF ALFALFA TO THE NITROGEN PROBLEM

There is another way of supplying the soil with nitrogen, viz.: by growing plants which have the power to take up free atmospheric nitrogen and fix it in the soil. One of the most remarkable discoveries in science was the fact that certain plants can do this and the way in which the nitrogen from the air becomes fixed through the agency of certain minute organisms (bacteria) which take nitrogen gas from the air that passes into the soil and so change it that it becomes food for plants. These bacteria work in connection with plants* belonging to the pea family, pease, beans, clover and other legumes, by producing little bunches or nodules on the roots in which they live.

There is a different organism for each kind of plant. They are spread through the soil and take up their abode on the roots of the plant to which they are related when it is grown, and the plants do not grow well if the organisms are absent.**

Alfalfa is hardy enough to stand our climate, easy to grow, gives as large or larger money returns from the land as will grain*** and improves the soil at the same time at no expense to the farmer.

The fixation of nitrogen by alfalfa overcomes the principal difficulty with arid soils and a rotation of crops in which alfalfa is one, practically solves the fertilizer problem over a large part of the west.

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*These bacteria are low forms of plants. When different plants live together for the mutual benefit of both, it is technically known as "symbiosis." There are many instances of symbiosis in the plant world.

**The minute organisms which work with alfalfa seem to be abundant in our soils. If they were absent the plants would not do so well, if they did not entirely refuse to grow. If alfalfa does not thrive, inoculating the soil with them might remedy the difficulty. Such inoculation has been put into practice with clover and the Germans have put the bacteria on the market for this purpose under the name of "Nitragin." It is necessary to get the right kind of bacteria, however, and I do not know that the one for alfalfa has ever been sold.

***For information in regard to alfalfa as a hay crop in Wyoming, see Wyoming Station Bulletin No. 43.

ALFALFA IMPROVES THE PHYSICAL CONDITION OF SOILS

Besides fixing nitrogen in the soil alfalfa improves its tilth or physical condition. The plants shade the land, prevent the rapid loss of water by evaporation and the rise of alkali salts to the surface. The roots have an important mechanical effect also. They grow to large size and penetrate to unusual depths in the subsoil. When the land is plowed to destroy the alfalfa, the roots decay, producing humus which aids in loosening the soil, holds moisture and helps other plants make use of the nitrogen which has accumulated. It is not necessary to plow under a crop of growing plants to secure the improvement though green manuring in this way is often practiced with good results. At Wheatland the superintendent of the sub-station farm, Mr. M. R. Johnston, practiced plowing under the last crop in the fall. The first and second crops were cut for hay which he states paid for the expense ot planting and use of the land and made the fertilizer cheaper than any other which could be applied.

Alfalfa also solves the weed problem. Where land has become infested with weeds, growing alfalfa two or more years will entirely clean them out of the land. Even foxtail*, which is so troublesome in parts of Wyoming, succumbs to alfalfa treatment. We can not expect to destroy foxtail everywhere this way, as it grows in places not suitable for alfalfa, but where alfalfa will grow and is cut two or more times in a season, foxtail or any other weed which may be present soon disappears.

ROTATIONS WITH ALFALFA.

Where alfalfa is used in rotation with other crops, the texture and richness of the soil is improved and the land is kept highly productive, providing of course it is not poor in plant foods which are usually abundant. A good rotation for the Laramie plains would be, beginning with the virgin sod; first year oats, second year potatoes with fertilizer, (stable manure) if possible; third year alfalfa sown on the potato ground without replowing, having it smoothed and leveled. The alfalfa may be left on the land any number of years. Then, beginning with alfalfa, which is to be plowed for other crops, would recommend, first year wheat, oats,, barley or potatoes. If crops are good it may be put in grain two or more years. The first year there may be alfalfa growing with the grain, as the plow may not cut off all the roots, but it will do no harm, as the grain roots are small and feed in the surface soil while the alfalfa feeds from below. Follow the grain with potatoes or other cultivated crop and then alternate grain and potatoes for a few years or until the land shows signs of running out, when it should be again put into alfalfa. If land is scarce it may be sown with a light seeding of oats as a nurse crop but for our high altitudes we have found it better to plant the alfalfa alone.

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*The grass popularly called "foxtail" in the west is not the common foxtail of the East, which is a valuable grass. The grass under this name with us is a wild barley (Hordeum jubatum), sometimes known as Squirrel Tail Grass. For an account of it as a stock pest in Wyoming, see Wyoming Station Bulletin No. 19, by Prof. Aven Nelson.

ALFALFA AS A FERTILIZER ON THE LARAMIE PLAINS

We have carried out an experiment at the station farm to show the value of alfalfa as a fertilizer.* While only one year's crop has been raised since plowing up the alfalfa, the results are well worth considering. In order that an understanding of the full effect of having grown the alfalfa on the land for a number of years may be had, we give a full historical report of the acre plat on one half of which alfalfa was grown and plowed under for the pro-

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*It is a pleasure to acknowledge the efficient help Mr. W. H. Fairfield has rendered in the work of the department. He carefully managed this experiment, and his field notes and records make the results accurate and valuable. Mr. A. H. Danielson has also given efficient aid.

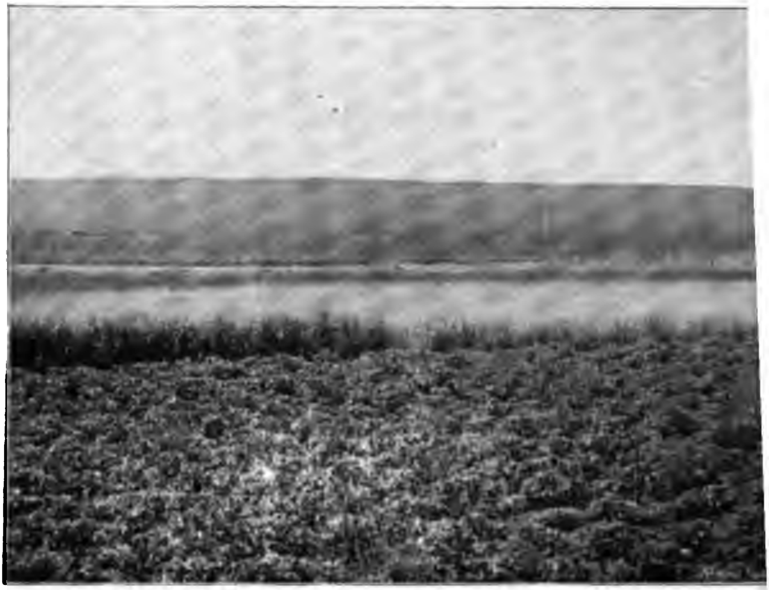

Fig. 1.

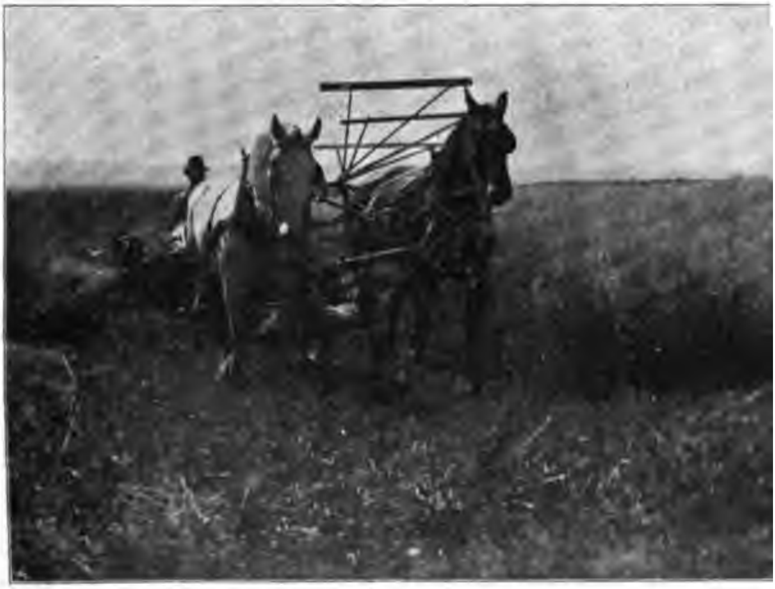

Fig. 2.

PLATE II.—*Fig. 1. Oats and Potatoes on Alfalfa and other ground. Left side of picture where Oats are heavy is Alfalfa ground. Fig. 2. Cutting Oats on Alfalfa ground.*

duction of other crops and on the other half has been grown crops other than alfalfa in rotation for the same length of time.

HISTORY OF ACRE PLAT 8.

1891.—In May the virgin soil was broken to a depth of five inches, and was planted on June 3 to strips of Indian Millet, German Millet, Jerusalem Corn, Kaffir Corn, Hemp, Sorghum, Sunflowers, Castor Beans and Corn. These crops did not mature and no record is at hand. to show that they were harvested.

1892.—The whole plat was plowed to a depth of eight inches in May or latter part of April, divided into fourths and planted June 2d to pease and beans with press drill and the land rolled after planting. Scotchman Pease and Boston Small Pea Beans were frosted before ripe and not harvested. Canadian Field and White Canada Pease ripened partial crops. They were harvested September 1 to 5 and yielded 5 to 7 bushels pease per acre. They were frosted August 29th.

1893.—On April 17th the whole plat was plowed ten inches deep, harrowed twice April 21 and rolled. May 1 the north half of the plat was sown with alfalfa, broadcast, at the rate of 20 pounds seed per acre. The south half of plat was planted to two kinds of rutabagas.

NORTH HALF.	SOUTH HALF.
Alfalfa.—A good stand was not secured. Was not harvested this year.	**Rutabagas were all destroyed by flea beetles, so no crop was produced.**

1894.—In winter of 1893-4 twelve loads stable manure were distributed as nearly even as possible over the plat. The whole acre was again plowed eight inches deep and harrowed twice.

NORTH HALF.

April 27, resown with alfalfa at rate of 39 pounds of seed per acre. Good stand and made excellent growth. A few bunches of previous years planting which were not cut off by plow growing. Harvested Aug. 16. Yield, 1967 lbs. cured hay per acre.

SOUTH HALF.

Two rows of broom corn 30 inches apart planted along one side. Season too short for it to mature. The remainder of the half acre was planted to varieties of potatoes on May 9, at rate of 1,000 pounds seed per acre. Harvested Oct. 1 to 4. Average yield of 50 varieties per acre, 9,900 pounds marketable potatoes. Average percent of tubers large enough for market, 87, or total yield including small potatoes, 11,300 pounds per acre.

1895.—

NORTH HALF.

Alfalfa was cut twice.

First crop harvested Aug. 6. Yield, 5,019 pounds per acre.

Second crop harvested Sept. 24. Yield, 2,557 pounds per acre.

Total yield for season, 7,576 pounds cured hay per acre.

SOUTH HALF.

Plowed eight inches deep on April 8. Sown to varieties of wheat, barley and oats in rows 15 inches apart with the exception of New Black barley, a small strip of which was sown with press drill eight inches apart. There was about the same area each of oats and barley, which occupied about one-fourth acre, and the wheat covered one-fourth acre.

Average yield per acre of seven varieties of barley, straw and grain, 3,536 pounds. Grain, 1,371 pounds.

Average yield per acre of six varieties of oats, straw and grain, 4,024 pounds. Grain, 970 pounds.

Average yield per acre of 15 varieties of wheat, straw and grain, 6,026 pounds. Grain, 1,768 pounds.

1896.—

NORTH HALF.

Alfalfa was cut twice.

First crop harvested July 7. Yield cured hay per acre, 1,641 pounds.

Second crop was harvested September 8. Yield cured hay per acre, 3,040 pounds.

Total yield per acre for season, 4,681 pounds.

Hail storm injured the first crop, which accounts for small yield.

SOUTH HALF.

April 22-23, plowed eight inches deep. Harrowed, leveled and sown with press drill to varieties of barley at the rate of 100 pounds seed per acre, in strips running east and west. Straw produced was short and yield small.

Average yield per acre of nine varieties of barley, grain, 895.5 pounds.

September 3, land was plowed about eight inches deep.

1897.—

NORTH HALF.

Alfalfa was cut twice.

First crop was harvested July 16. Yield of cured hay per acre, 3,860 pounds.

Second crop was harvested September 9. Yield of cured hay per acre, 3,860 pounds.

Total yield for season per acre, 7,720 pounds.

SOUTH HALF.

April 20, leveled and drilled with Lincoln oats at different rates of seed per acre, from 40 to 120 pounds.

Average yield of grain and straw per acre, 2,617 pounds. Grain, 1,076 pounds.

1898.—

NORTH HALF.

Alfalfa was cut twice.

First crop was harvested July 17. Yield per acre of cured hay, 4,759 pounds.

Second crop was harvested September 8. Yield per acre of cured hay, 3,909 pounds.

Total yield for the season, per acre, 8,668 pounds.

SOUTH HALF.

April 16-19, plowed eight inches deep and leveled. April 29, planted to spring rye at the rate of 114 pounds of seed per acre. Harvested August 13.

Yield per acre, straw and grain, 1,580 pounds. Grain, 556 pounds.

On September 22 and 23 the whole plat was plowed to a depth of about 8 inches. It was not very well done on the north side, as the plow used was not suited to the purpose and all the alfalfa roots were not cut off.

Since cropping was begun on the two parts of the plat separately in 1894 the following crops have been produced on each half of the plat. The yields here are for each half acre instead of yields per acre as reported above:

NORTH HALF—ALFALFA.
One-half Acre.

	Pounds.
1894	984
1895	3788
1896	2341
1897	3860
1898	4834
Total	15,307

SOUTH HALF—OTHER CROPS
One-half Acre.

	Pounds.
1894—Potatoes	5650
1895—Grain and straw	2264
Of which amount the grain is	685
1896—Grain and straw	*1280
Grain alone	448
1897—Grain and straw	1309
Grain alone	538
1898—Grain and straw	790
Grain alone	278
Total potatoes	5650
Total straw and grain	5643
Total grain	1949

*Estimating that grain is 0.35 percent of grain and straw together.

A rough estimate of the value of the crop from each half acre for the above five years at local prices would be approximately for north half, alfalfa, $60* Potatoes and grain from the south half, $69. The total expense of harvesting the alfalfa should not exceed $10.00, estimating from what the actual cost per ton would be on large areas. The south half should have expense of preparing the land for crop each season deducted as well as value of seed, harvesting and sacking the potatoes and threshing the grain.

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*This estimate is conservative, as it is based on a value of $8.00 per ton in the local market. The scarcity of alfalfa hay makes it of greater value than native hay, and the price of native hay has rarely been lower than $8.00 per ton, while a part of the time it has brought twice this amount. All the alfalfa could undoubtedly have been sold for $10 to $15 per ton, and certainly would have brought enough more than $8.00 to pay all expense of marketing it.

A rough estimate of this expense on the south half of the plat would place it at about $25. This would make the net value of the alfalfa from one-half acre $50, and of grain and potatoes from one-half acre for the same time $44. Comparing the crops produced each year, the production increased from the alfalfa land, while it decreased to such an extent from the plowed ground that the last crop of rye gave barely ten bushels of grain per acre, though last season it produced much better yields of wheat and oats.

This brings the history of acre plat eight down to the spring of 1899 and the following report shows the value of having grown alfalfa on the land for other crops. The alfalfa stubble was plowed under in the fall after the second hay crop of 1898 had been removed.

YIELDS OF WHEAT, OATS AND POTATOES ON ALFALFA LAND.

April 25, 1899, acre plat 8, all of which had been plowed the previous fall, was harrowed twice and leveled or planked twice. The east one-third of the plat was planted to wheat by drilling north and south, so one-half would be on the alfalfa land and the other half on that part of the plat which had been growing other crops. In like manner oats and potatoes were planted on the other two-thirds of the plat. In planting the potatoes the west third of the plat was again plowed, dropping the seed in every third furrow. The comparative lengths of straw and heads of the oats and barley are well shown in our illustration made from a photograph of as nearly average plants as could be selected from each portion of the plat. The appearance of the oats at each end of the plat is shown in the illustration used as frontispiece. The divisions were not made equal, and the area of each crop varied somewhat, so the results are all reported on the acre basis. What the lasting effect is on the soil will only be known after other seasons' crops have been studied.

WHEAT—The increase in yield on alfalfa land is shown in Table 1. Over 60 percent larger yield was obtained on the north side of the plat where alfalfa had been grown before, and the grain weighed more per bushel. However, the conditions of growth being so much better, it took longer to mature and the grain was not fully ripe when it was lightly frosted on August 24. There was a smaller number of smutted heads also in the grain on the alfalfa end of the field. At local market prices an increase of seven to twelve dollars' worth of wheat per acre was the result of using alfalfa ground on which to plant it. As shown above, fertilizing the land with alfalfa cost nothing, as the value of the hay produced was equal to other crops on the other part of the land.

TABLE I.—*Wheat. Scotch of Scotch. Laramie, 1899.*

PART OF PLAT	Area	Date Planted	Date Ripe	Height of Grain	Length of Heads	Per cent of Smut	Yield per acre Straw and Grain	Yield per acre Grain	Weight per bushel
	acres			*ft.*	*ft.*		*lbs.*	*lbs.*	*lbs.*
South (rotation)...	0.14	April 27	Sept. 7	3.00	0.25	17.6	2895	1085	56
North (alfalfa land)	0.17	April 27	Sept. 14	3.75	0.30	16.8	5118	1803	58
Gain on alfalfa land	....	....	....	.75	0.05	0.8	2223	718	2

OATS.—(Table 2.) The yield of grain was about 48 percent greater on the alfalfa land than on the land which had been growing potatoes and grain. Nearly 78 bushels per acre was produced on the north (alfalfa) end of the plat and 37 bushels per acre on the other land, using the weight of 32 pounds per bushel for the computation. The grain stood nearly one and one-half feet higher and the heads averaged nearly two inches longer, but the grain took much longer to ripen on the alfalfa land. Unfortunately the comparative weight of the oats for the two kinds of land can not be given, as one of the records was lost. They weighed 43 pounds per bushel from the alfalfa ground. Plowing under alfalfa stubble increased the value of the crops about $16 per acre at the market price in Laramie, and the fertilizing was done without expense.

TABLE II.—*Oats. Highbred. Laramie, 1899.*

PART OF PLAT	Area	Date Planted	Date Ripe	Height of Grain	Length of Heads	Yield per acre Straw and Grain	Yield per acre Grain	Weight per bushel
·	*acres*			*ft.*	*ft.*	*lbs.*	*lbs.*	*lbs.*
South (rotation). . . .	.14	April 27	Aug. 26	2.8	0.50	2744	1193	. . .
North (alfalfa land). . . .	.16	April 27	Sept. 6	4.2	0.65	7529	2484	43
Gain on alfalfa land . .	. . . .	. . . .	. . . .	1.4	0.15	4785	1291	. . .

POTATOES.—The potato crop of last season was a failure. It was the first season since 1893 that potatoes have not produced good yields on the Experiment Farm. The reason seems traceable to the unusually short season with cold nights and generally poor growing weather. However, our results to show the effect of plowing under alfalfa for potatoes are comparable and show the effect on the crop as well as would be the case if the yields were large. The yield of marketable potatoes was increased over 62 percent on the alfalfa land and the potatoes averaged larger in size. The increased cash value of the crop was about $16 per acre at local market prices, at no cost for the improvement in the soil which caused the increase.

TABLE III.—*Potatoes. Early Ohio. Laramie, 1899.*

PART OF PLAT	Area	Date Planted	Date Harvested	Yield per acre Marketable	Yield per acre Small	Total Yield per acre	Per cent Marketable
	acres			*lbs.*		*lbs.*	
South (rotation). . .	0.13	May 18,19	Sept. 30 Oct 7	2616	528	3144	83.2
North (alfalfa land). .	0.16	"	"	4219	663	4882	86.4
Gain on alfalfa land .	. . . .	. . . . .	. . . . . .	1603	135	1738	3.2

SUMMARY.

The most important fertilizer for the arid region is nitrogen.

Some plants, of which alfalfa is one, have the power to fix in the soil free nitrogen of the air. They do this by means of micro-organisms which form bunches or nodules on the roots.

Therefore growing alfalfa on the land increases the amount of nitrogen in the soil and practically solves the fertilizer problem for the west.

Alfalfa also improves the soil tilth by shading the ground and adding humus to the soil by the decay of its large, deep-growing roots.

Growing alfalfa destroys weeds.

The value of alfalfa harvested from one-half acre of land for five years at Laramie was about $50 more than the cost of producing it.

The value of potatoes and grain from an adjoining half acre for five years was about $44 more than the cost of producing at local prices.

When the alfalfa land was plowed and planted to wheat it produced $8 to $12 more value in wheat per acre than the land which had grown potatoes and grain before.

When alfalfa land was plowed and planted to oats it produced $16 worth of grain more than land which had grown potatoes and grain before.

When alfalfa land was plowed and planted to potatoes it gave $16 worth more of potatoes per acre than was obtained from land which had grown potatoes and grain before.

By growing alfalfa, the above increase of yields and values were produced with absolutely no cost for fertilizing the land.

UNIVERSITY OF WYOMING.

Agricultural College Department.

WYOMING EXPERIMENT STATION,

LARAMIE, WYOMING.

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A PRELIMINARY REPORT

. . . ON THE . . .

ARTESIAN BASINS OF WYOMING.

WILBUR C. KNIGHT.

Bulletins will be sent free upon request. Address: Director Experiment Station, Laramie, Wyo.

Wyoming Agricultural Experiment Station.

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A PRELIMINARY REPORT

. . . ON THE . . .

ARTESIAN BASINS OF WYOMING.

W. C. KNIGHT.

Introduction.

The object of this bulletin is to place before the citizens of Wyoming a preliminary treatise on the artesian basins of this state and show how this information is available for the agriculturist, stockmen and communities in general. In order to do this it has been found necessary to introduce in a very brief manner a resume of Wyoming geology. This is of necessity technical, since there are no common names to be substituted for scientific ones. I realize fully how difficult it is to popularize a subject of this kind and at the same time make it comprehensive without writing page upon page of explanation that would increase the bulletin beyond a reasonable limit. If I can present the scientific information in such a manner that the citizens of this state can understand the essential features of our artesian basins and be able to locate artesian wells, I will feel that I have fully accomplished my purpose.

Without a scientific treatise relating to the artesian basins there would be no means of discussing the basins, locating them, or referring to the water-bearing zones. Scientific terms in connection with the geology will, as a rule, be defined, so that those who are unfamiliar with the history of our earth can read intelligently. To aid the explanations many illustrations are used and an accompanying map will aid materially in showing the distribution of the many formations.

The question of securing good artesian water in any part of Wyoming is a very important one. Already, nearly all of the available water from our streams has been appropriated, and the springs and tiny brooks are being fenced up, so that in a few more years not many natural watering places will remain open for stock of any kind. Unless wells are drilled large tracts of land in our state, such as the Red desert, the desert north of the Rattlesnake mountains and country north of Casper will remain as they are today—winter sheep ranges—winter ranges because the flockmaster depends on snow to water his herd. If wells are to be drilled the artesian well is the most desirable. Unless the supply of water can be greatly increased large tracts of valuable land must remain as grazing land only—of little value to the owner since it produces so little, and an obstacle to the state because it cannot be taxed for hay or agricultural land in place of grazing. The Powder River country, which is as a rule low and fertile land, has not sufficient water to irrigate 10 per cent of the vast area. On the south side of the Ferris and Seminoe mountains agriculture is an impossibility under existing conditions, since there are no streams of any consequence along these ranges. North of the Shirley mountains conditions are similar, as they are in numerous other places in the state. Imagine what would happen if all of the country east of the Laramie mountains could be irrigated.

How far artesian wells will solve any of these problems remains for experiment to prove; but without question they will be found beneficial in many instances, and when a system of deep well drilling has been inaugurated the water supply will be sufficient to carry on irrigation on a large scale. One has to go only to Dakota to realize the possibilities of irrigation by means of artesian water. Artesian basins are numerous in Wyoming and some of them are very large and especially well located. So far but little attention has been given to this subject. A few shallow wells have been drilled in several counties, but none of them have gone to a sufficient depth to secure a large flow. Few, if any, have thus far contemplated sinking deep wells with a view of obtaining more than a slight flow. To those who wish to increase their present water supply I refer to the artesian wells of Dakota, where in a few instances water has poured forth under a pressure of 150 pounds per square inch and has been used as a water power as well as to irrigate with. The Dakota artesian basin depends largely upon the Black Hills for its water supply; possibly this may be augmented by the waters from the Big Horn mountains, but this is not probable. Judging from the source of the water in many of the Wyoming basins, the artesian wells in this state should equal any that have been drilled in South Dakota. The high mountains, clothed with pine and spruce forests, and the peaks of perpetual snow, furnish day by day a constant water supply which sinks down between the strata and may be tapped with a drill a thousand or more feet lower than the source.

The data employed in this bulletin have been collected by me during the last four summers. Occasional references are made to some of the early reconnaisance surveys; but all of the structural features have been workd out from field notes. The geological map embodies all that is known of the geology of Wyoming up to date. All of the early maps have been examined and their data used so far as it harmonizes with recent investigations. This map can only be considered reconnaisance work; hence an allowance will have to be made for variations in boundaries between eras and in a few places for structure. For example, the country east of Laramie peak and at the head of the Wind river are not well known and more than likely the geology of all of Uinta county north of the Oregon Short Line railroad needs careful revision. There are numerous small areas all along the east side of the Laramie mountains that have not been examined. There are in fact numerous places all over the state where greater detail can only be worked out by careful examination. The map has been constructed to illustrate the distribution of the various formations in the state and to act as a key to structural geology. For these purposes it will be found very reliable, and those interested in securing artesian wells will find it a valuable aid. No attempt has been made to show the topographical features, since only a very small portion of the state has been surveyed. Accompanying the bulletin there are nmerous geological sections which will be found to be indispensable in considering the structure of the various artesian basins.

Judging from what has been done in the past, it will be many years before the citizens of this state will attempt to increase the water supply by means of artesian wells and it may be possible that the state may have to lend aid to this very commendable enterprise. It will be well for our next legislature to consider the advisability of drilling test wells in the artesian basins where water is most needed, and in this way encourage ranchmen to drill for themselves. In case test wells are put down by the state, the location should be carefully selected and only deep wells drilled. Otherwise many would be discouraged on account of slight flows.

I take this opportunity to thank the United States Geological Survey for electrotypes of the Fort Benton and Niobrara fossils, used in this bulletin; also to thank Prof. Charles Fulton for assisting me in drawing the map and sections, and Mr. Frank Bond for producing such excellent drawings of fossils, which add so much to the bulletin.

A Geological Sketch.

In the following pages will be found a very brief description of the geological formations known in Wyoming. An attempt has been made to describe the various formations so that people residing in any part of the state can work out for themselves the geology of their region and conclude whether or not they wish to attempt drilling for artesian water. Prior to describing the formations I have introduced a scheme showing the names and subdivisions of geological time as applied to Wyoming geology. The top of the scale represents the latest formation and the bottom the oldest.

- CENOZOIC
  - Pleistocene
    - Recent.
    - Champlain.
    - Glacial.
  - Tertiary
    - Pliocene ?
    - Miocene.
    - Oligocene.
    - Eocene
      - Bridger.
      - Green River.
      - Wasatch.
- MESOZOIC
  - Cretaceous
    - Laramie
      - Fort Union?
      - Lower Laramie.
    - Montana
      - Fox Hill.
      - Fort Pierre.
    - Colorado
      - Niobrara.
      - Fort Benton.
    - Bear River.
    - Dakota.
  - Jurassic
    - Como.
    - Shirley.
  - Triassic.
- PALEOZOIC
  - Permian.
  - Carboniferous
    - Upper.
    - Lower.
  - Devonian.
  - Silurian (absent)
  - Ordovician.
  - Cambrian
    - Upper.
    - Middle.
- PROTEROZOIC (EOZOIC)
  - Algonkian
    - Not subdivided.
- AZOIC
  - Archæan
    - No natural subdivisions.

Before taking up the geological discussion it must be understood that nearly all of the stratified rocks have been deposited in seas or fresh water lakes. The name stratified rocks includes limestones, sandstones, shales, slates, conglomerates, as well as most of the clays and marls. During the geological history of our earth all, or nearly all, of the land has been covered with water, and usually many times. If there were no seas or lakes, no rocks were deposited, and the formation is absent. One can form a better idea of geological time if he will consider that there have been constant changes in both sea bottom and land surfaces. The period in which a sea bottom was gradually settling means that there was deposited a very thick band of rocks. If the sea was deep and water clear, limestones were made. If clear, limestones were also made in shallow water. Along coast lines, where sand was produced, sandstones were formed, together with other strata as conglomerates and breccias. In gulfs and bays where there were large rivers emptying, fine sediment and mud accumulated, which were later compressed into shale. If a formation is present in Wyoming, it means that a sea or lake existed during that period; if absent, it means that the state, or that part of the state in which the strata are absent, was dry land. In the same way we can judge of the duration of a geological period by considering the thickness of the rocks deposited. For example, the Paleozoic rocks in Wyoming are not to exceed 3,000 or 4,000 feet thick, while in Pennsylvania they are over ten times that thickness. From this we gather that Wyoming was dry land for the greater part of the Paleozoic era.

Azoic Era.

This represents geological time prior to the appearance of life on earth. The rocks are chiefly granite, and none of the metamorphosed sediments are included.

THE ARCHAEAN PERIOD.

The name Archæan applies to the oldest rocks that we know anything about on our earth. Usually they are granite, gneisses and schists, with granite predominating. Originally the Archæan not only included the above rocks, but also very thick bands of metamorphosed sediment, which have recently been separated from the Archæan by the United States Geological Survey and called the Algonkian. In accordance with the Canadian geologists, the Archean is divided into the Laurentian and Huronian, the Huronian being largely metamorphosed sediment. Under the more recent classification the Huronian belongs with other formations to the Algonkian. The name Archæan restricted as given above, has in it no evidence of life or anything pertaining to life. The rocks were in all probability of eruptive origin and represent the so-called crust of our earth prior to the deposition of any sediment. Other views are held as to the origin of these rocks; but the question of origin cannot be discussed here. The Archæan, then, is the fundamental or primary formation that formed at one time the entire sea bottom and the entire land masses—a formation universal. All of the sedimentary depositions have tended to bury these oldest rocks and in consequence there are only occasional areas exposed, and the most of these in Wyoming occur along the crests of the mountain ranges; when huge folds elevated them while they were covered with many thousand feet of sedimentary rock. The sedimentary rocks have since been removed by erosion. In the Sweetwater valley there are numerous peaks of granite that appear to have been constantly above the sea since the beginning of the Archæan era. There was in all probability a large Archæan land mass in this region that remained above the sea from Archaean time up to nearly the close of the Tertiary, when it was depressed and covered with a few hundred feet of Tertiary strata. Typical Archæan exposures can be seen at Sherman, Laramie peak, east of Whalen canon, along the Big Horn, Wind River, Gros Ventre, Medicine Bow, Ferris, Seminoe and Owl Creek ranges, along the Sweetwater river, a few miles northwest of Rawlins, and north of Clark's Fork, in Big Horn county. These rocks are usually mineral-bearing and when cut with dikes of porphyry make the conditions ideal for the occurrence of all of the precious metals.

The only way that this, the oldest of formations, can affect the artesian basin, is that it forms the highest mountain ranges, where vast quantities of snow accumulate during the winter to feed the basin with water during the summer months, and also forms a bed rock in many localities on which rests the lowest and the greatest water zones in the state. The term bed-rock as used in connection with this bulletin, means the Archæan granite. Springs are quite numerous in this formation, but since the rocks are not stratified there are no water-bearing zones that can be traced. Wells of the very best water can be found in the granite rocks and occasionally the water will rise to the surface and flow in a small stream. Usually wells put down in these rocks have to be provided with some means to elevate the water.

Proterozoic Era.

(EOZOIC.)

This marks the first era of sedimentation; also the introduction of life on earth. The rocks are usually sedimentaries that have undergone extensive metamorphism, and are schists, marbles and quartzites, together with intrusive bands of eruptive rock. They are also acutely folded and nearly all of the evidence of fossil remains has been obliterated. The Proterozoic also marks the first great mountain-making period of our earth. These rocks are found unconformable with the Archæan.

ALGONKIAN.

Up to the present time the Algonkian rocks of Wyoming have been referred to the pre-Cambrian and have not been separated from the Archæan. They form important bands in numerous localities and have in this bulletin, so far as the data have warranted, been separated from the Archæan. The formation is composed of schists in great profusion, marbles, quartzites and these cut with dikes of eruptive rocks. The strike of the entire formation varies from north to northeast, and the dip of the strata is seldom less than 65 or 75 degrees. It is unconformable with the Archæan and is found in great granite basins. The thickness of the entire series has not been absolutely measured, but including the eruptive band, which does not form an important part, the maximum thickness in Wyoming is about 20,000 feet. Typical areas have been found in the Black Hills in Wyoming, and occasional outcrops to the southwest from that place to the Hartville hills—one exposure being east of Lusk, another at Rawhide Butte, and a large one in Whalen canon. They also occur at Halleck canon, Plumbago canon, in the Medicine Bow mountains, nearly all of the Sierra Madre mountains, in the Seminoe mountains and in the Sweetwater mining district of the Wind River range. None of these localities have been examined in detail; but sufficient work has been done to prove that these rocks were at one time sedimentary and that they have been changed by metamorphism to schists. In the Sweetwater districts the rocks are chiefly schists; but there are many bands of eruptive rock that form dikes which follow the strike of the formation

We have every reason for believing that life was born on earth during the Algonkian period; in fact a few fossils have been reported from rocks supposed to belong to this formation. At the close of this period in Wyoming there is evidence that great mountain ranges were formed. A very prominent one extended from the Laramie mountains north and east to the Black Hills, the remnants of which are still visible. A second prominent range extended from South Pass northeast to an unknown distance. After the mountains were formed they remained dry land a sufficient length of time to have these ranges reduced to mere hills, and in many places to almost plains, and upon their upturned edges was deposited the Cambrian strata.*. On account of the strata being highly inclined and ther being no basins in which water could accumulate under much head, none of this series can be seriously considered as valuable artesian basins. However, a small flow of artesian water may be found in several of these areas.

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*In Michigan, the Algonkian rocks contain very extensive deposits of both iron and copper and usually they are mineralized wherever found. In Wyoming mines of gold, copper, silver, lead and iron occur, in the camps at South Pass, Encampment, Seminoe and the Black Hills.

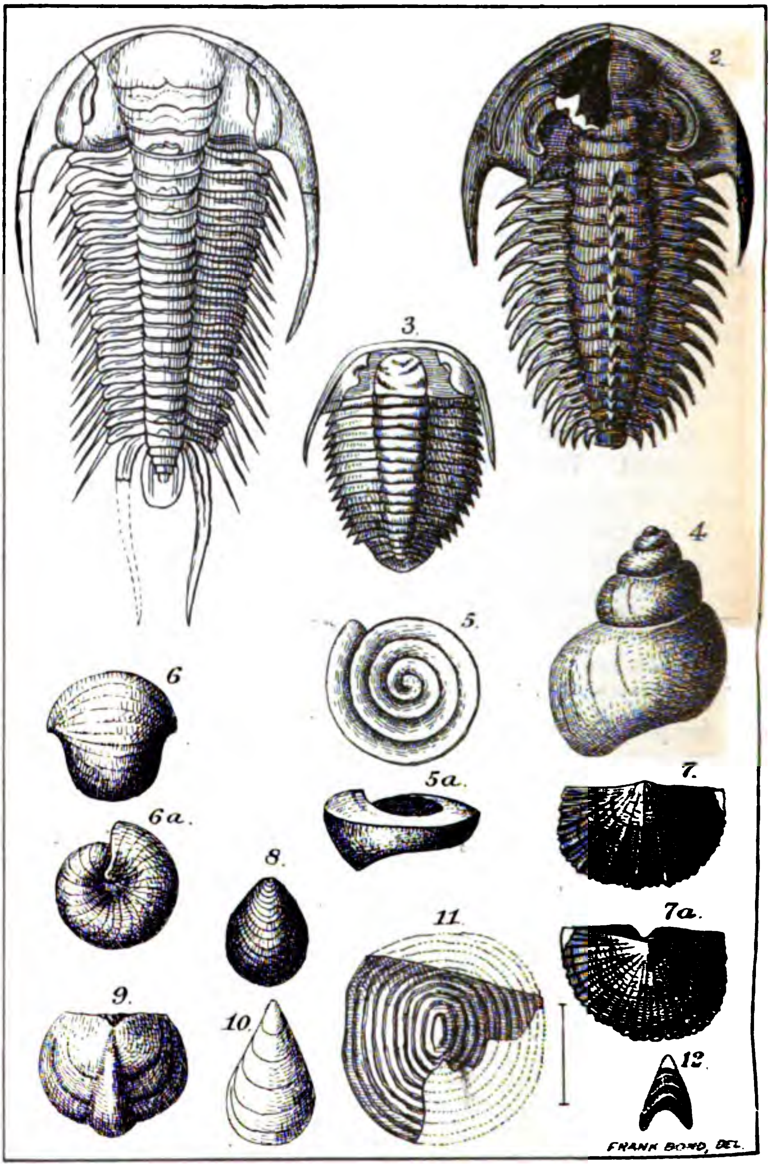
The Paleozoic Era.

The Paleozoic rocks in Wyoming rest unconformably upon the Archean and Algonkian, and vary in thickness from 1,000 to 4,000 feet. Along the Appalachian mountains rocks of the same era have a thickness of 40,000 or 50,000 feet. In Wyoming the Paleozoic rocks are nearly all limestones, with a few bands of calcareous sandstone, some sandstone, quartzites and conglomerates. These occur along the mountain sides, dipping at various angles and sometimes reaching elevations of 9,000 or 10,000 feet. Along the western flank of the Big Horn and the eastern flank of the Wind River range these rocks extend from the granite to the base and practically cover the mountain slopes. Upon reaching the foot of the ranges the Paleozoic rocks dip beneath later formations. From a life standpoint the Paleozoic era was the first important period in the world's history. Life had existed for some time prior to the advent of this era; but it was represented so far as we know only by a few inferior sea animals and the impressions of these have been largely obliterated through the metamorphism of the strata. Conditions changed at the commencement of the Paleozoic and for the first time in the world's history the seas were teeming with invertebrate life. Associated with these were numerous kinds of sea weeds. The life was very simple to start with, but as geological time went on it became more and more complicated. The sea life changed from invertebrates to vertebrates (fishes). Some of the invertebrates of the sea developed into land animals (insects), so that from the beginning to the close the era is one of great biological progress. From the fishes, amphibians developed, and from the amphibians reptiles, which represented the highest type of animal life known at the close of the Paleozoic. The plant life also developed in a similar way. The sea weeds developed into land plants and these into shrubs and finally into large trees, which made great forests, but the highest form of vegetable life was far from representing the deciduous trees of today. From an economic standpoint the Paleozoic in Wyoming is of but little importance, the building material and the production of iron, oil and gas being the only products. In the east and in other countries, it was in the Paleozoic that the great Carboniferous coal fields were formed. Along the Appalachian mountains there are great fields of oil and gas, as well as beds of salt, clay, gypsum and iron ore. In the Mississippi valley these rocks contain vast deposits of lead and zinc. In Wyoming, this series, although very thin, must be considered as essential bands, since they are found extending to high points along the mountains and act not only as large storage reservoirs but also furnish hydrostatic pressure. Again they are important since the water found in them is usually quite free from alkali and other injurious ingredients.

CAMBRIAN PERIOD.

This was the first geological period in which life became of much importance on our earth. The records of the rocks prove conclusively that all life was confined to the sea, and was represented by lower forms of the animal and vegetable kingdoms. While deposits thousands of feet thick were collecting in the eastern part of the United States, Wyoming was dry land, but became partly submerged near the close of this period. There are no Cambrian rocks known in southeastern Wyoming; but in the central part and in the north and west, the strata reach a thickness of from a few hundred to about 1,000 feet. The lower portion of this series is made up of conglomerates and sandstones that are usually metamorphosed into quartzites; the upper is nearly all limestone. The later beds are exposed only in northern Wyoming, while the reddish sandstones, conglomerates and quartzites are exposed as far south as Rawlins and form the major part of the Cambrian northward into the Wind River and Big Horn mountains. These strata form the lowest bands in many of the artesian basins, since they rest either upon the Archean or upturned edges of the Algonkian rocks. This is a very important water-bearing formation and will probably be the greatest in any of the basins where the Cambrian rocks occur. They will usually be found encircling the Archæan masses, and typical exposures can be seen at Whalen canon, east of Sundance, northwest of Rawlins, along the Grand Canon of the Platte, near Miner's Delight, along the Big Horn and Wind River mountains.

PLATE I.



FRANK BOND, DEL.

SOME CAMBRIAN FOSSILS SELECTED FROM VARIOUS SOURCES.

[Explanation of Plate I.]

No. 1—*Paradoxides bohemicus,* Barr.
No. 2—*Olenellus kjerulfi.*
No. 3—*Olenus truncatus,* Brisnn.
No. 4—*Holopea sweeti,* Whitfield.
No. 5—*Ophileta primordailis,* Whitfield.
5*a*—Side view of No. 5.
No. 6—*Bellerphon antiquatus,* Whitfield.
No. 7—*Orthis (Protorthis) billingsi,* Walcott.
No. 8—*Linnarssonia transversa,* Walcott.
No. 9—*Triplesia (Camarella) primordialis,* Walcott.
No. 10—*Lingulepis antiqua,* Hall.
No. 11—*Stenotheca arcadia,* Walcott.
No. 12—*Matheria variabilis,* Walcott.

THE ORDOVICIAN PERIOD.

(LOWER SILURIAN).

At the close of the Cambrian all of Wyoming was elevated above the sea and remained so for long periods of time; but the northern half of the state was submerged near the close of the Ordovician period, which allowed strata to accumulate to a thickness of from 600 to 900 feet. These rocks are light colored, thick bedded limestones and sandstones, but contain very little fossil life. The Ordovician period was one of great importance in geological history. Prior to this time the life was represented by sea life only and the highest types were invertebrates. During this period insects made their first appearance on the land and fishes in the sea. It was also marked by the general advancement of invertebrate life, and trilobites reached their maximum of development. Rocks of this period are found along the Wind River and Big Horn mountains, where they extend to points of considerable elevation. The strata, being sandstones and limestones, are of great importance in the vicinities where they occur, and are practically as valuable for artesian wells as the Cambrian. The supply of water will usually be large and will flow under great pressure. Good exposures of Ordovician can be seen two or three miles northeast of Miner's Delight, along Beaver creek, near the head of Warm Spring creek, a few miles above Dayton, and eight or ten miles west of Hartville. In Wyoming nothing of comercial importance has been found associating within these rocks except building material. In Ohio the Ordovician produces natural gas and petroleum.

SILURIAN PERIOD.

(UPPER SILURIAN).

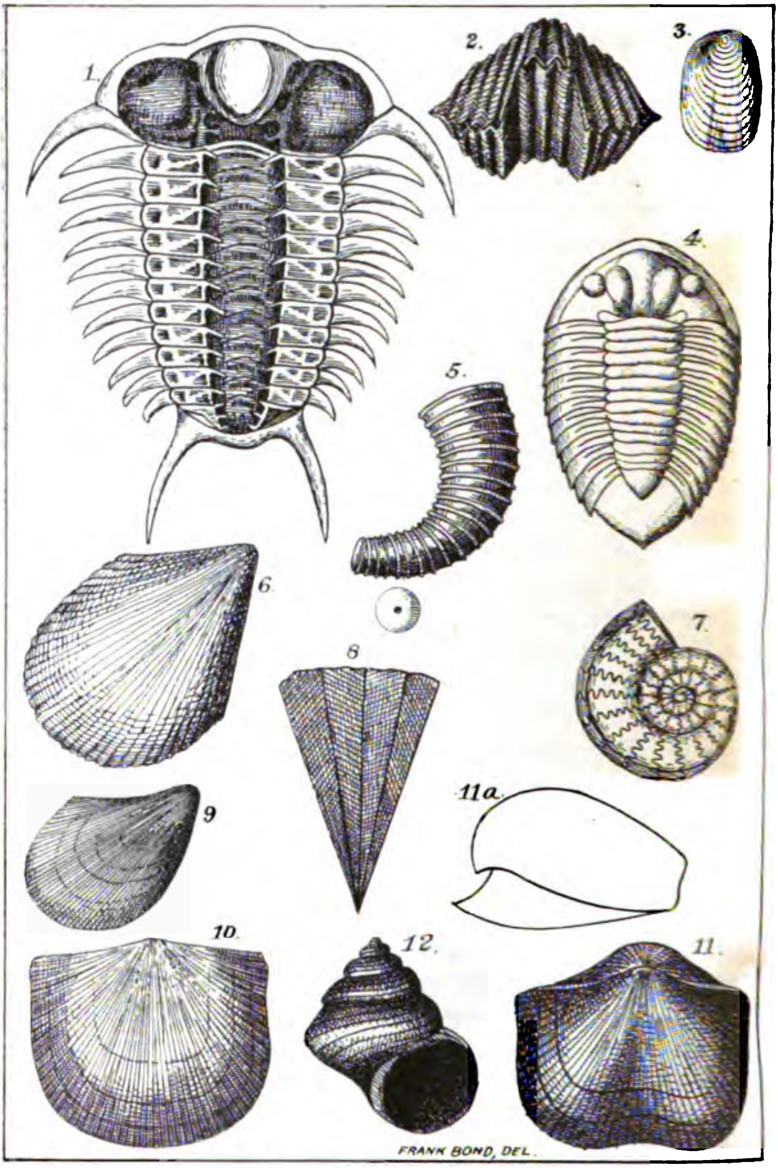
So far as known there are no Silurian rocks in Wyoming. Many geologists have reported the Silurian, and in the reports of Hayden the term is used. In the most of these cases the Cambrian was considered Silurian, together with the thin band of Ordovician or Lower Silurian. So far as our present investigations have proven, Wyoming was dry land during the Silurian, as it had been the greater portions of the Cambrian and Ordovician. Owing to the absence of the Silurian rocks, and slight importance of the Devonian, plates of fossils illustrating these periods have been omitted.

DEVONIAN PERIOD.

This is the "Old Red Sandstone" period. By others it has been called the age of fishes. It is only recently that the Devonian has been reported from this state, and all that is at present known of it is confined to the northwestern corner of Big Horn county and Yellowstone park. It is highly probable that thin bands may also be found in the Big Horn mountains. In the eastern part of the United States they attain a thickness of several thousand feet, while in Wyoming they are only 250 feet. The strata are chiefly limestones in which there are a few typical species of invertebrates. No fishes have been reported. In considering the many phases in geological history, there are numerous important events that should be recorded; but only a very brief reference will be made. Prior to this period we have little or no evidence that forests ever existed; but during the Devonian they were extensive enough to form veins of coal. Vertebrate life was introduced on land in the form of amphibians (frog-like animals). The seas were filled with fishes. At no other period in the world's history did so many fishes live. They were not like the most of the fish that we are acquainted with today, but belonged to an old type which is represented in our rivers by the sturgeon.

In Wyoming the Devonian rests conformably upon the Ordovician. Nothing of economic importance has been re-

PLATE II.



SOME ORDOVICIAN FOSSILS.

[Explanation of Plate II.]

No. 1—*Ceraurus pleurexanthemus,* Walcott.
An Ordovician Trilobite.
No. 2—*Orthis (Platystrophia) biforata,* Hall.
No. 3—*Lingula quadrata,* Hall.
No. 4—*Lichas trentonensis,* Meek.
No. 5—*Crytoceras subanunlatum,* D'Orb.
No. 6—*Ambonychia radiata,* Hall.
No. 7—*Crytolites compressus,* Hall.
No. 8—*Conularia trentonensis,* Hall.
No. 9—*Ambonychia bellistrata,* Hall.
No. 10—*Rafinesquina alternata,* Meek.
No. 11—*Orthis occidentalis,* Hall.
No. 11*a*—*Orthis occidentalis,* Hall. Side view.
No. 12—*Cyclonema bilex,* Conrad.

ported from these strata; but in the east they supply both oil and gas, and in England they contain thin beds of coal. On account of the very limited occurrence these rocks enter into the structure of the Big Horn artesian basin only, and in this, in the northwestern corner, where the formations are nearly vertical along most of the outcrops. Consequently they deserve little or no attention. They will be found to be water-bearing and possibly there may be some tunnel propositions, where they may yield considerable water. Their high inclination practically bars them from furnishing wells.

CARBONIFEROUS PERIOD.

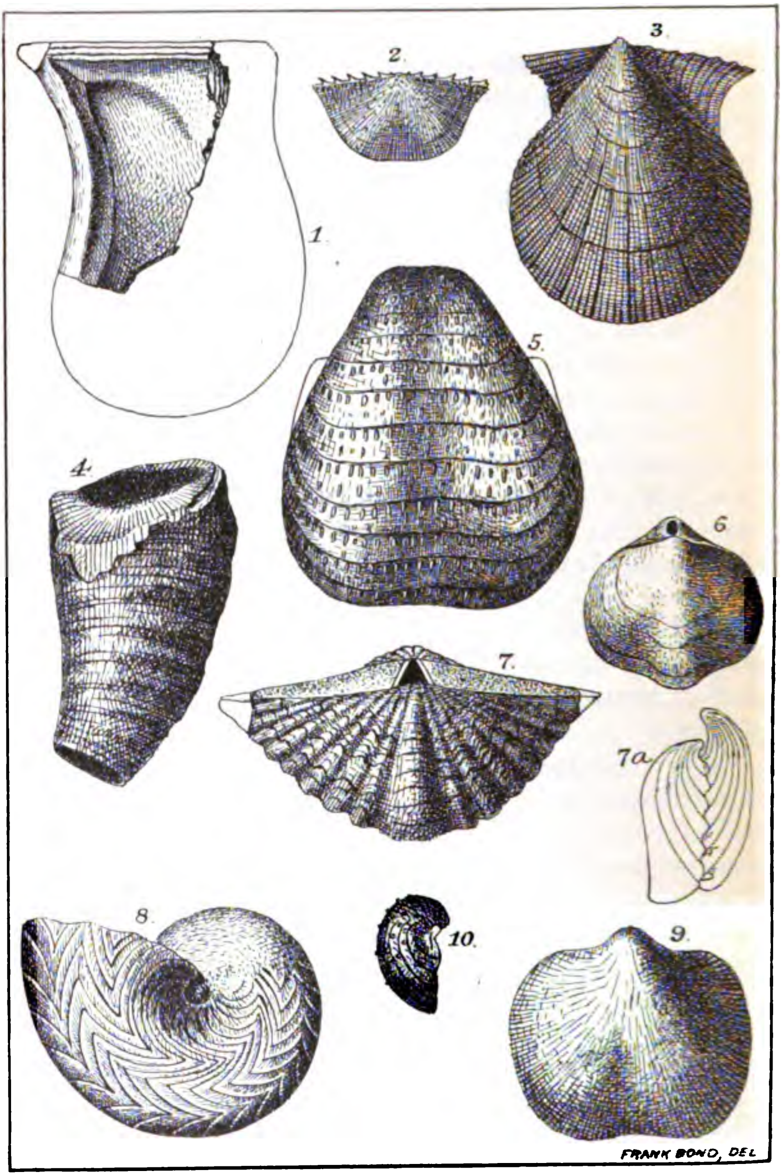
This period is separated into upper and lower divisions, both of which are represented in Wyoming; but neither is of much importance as compared with the Carboniferous formations of the Appalachian mountains. The lower Carboniferous series is formed only in the northern part of the state, where the strata are very thick bedded limestones. Near Miner's Delight there are strata of light colored limestone that are upwards of 50 feet in thickness. In the Wind River mountains this series of rocks has a thickness varying from 400 to 600 feet, but seem to thicken to the northward. The same series of beds have also been observed in the Black Hills and along the Big Horn range.

The upper Carboniferous marks a period in Wyoming geology in which the entire state with the exception of the Sweetwater valley was depressed and became a sea. Even the southeastern corner of the state, that had remained constant land since the close of the Archæan era, was submerged. This subsidence was quite late in the upper Carboniferous period and there are only thin bands of representative rocks, which are the first strata that are universally distributed in the artesian basins of Wyoming. In no instance have these rocks been reported to be over 2,200 feet in thickness, and this must be considered as the maximum if not an over-estimate. Usually the thickness is less than 1,000 feet. The strata are chiefly limestones with calcareous sandstone, and sandstones which vary in color from drab to pink and red. Along the Laramie mountains the lowest stratum is a grit and conglomerate, which has been considered to be Cambrian by some geologists; but there is no evidence to prove this suggestion.

The life of the Carboniferous shows an improvement on the life of the Devonian. The early forms of shell-fish that were so numerous in early Paleozoic periods have disappeared or are disappearing, and their places filled with higher and more complicated forms. Trilobites, that were the most common form of life during the Ordovician, have nearly disappeared at the close of the Carboniferous. The vertebrate life of the seas was made up of several types of fishes. Many of these were large sharks. The land vertebrates that are known were all amphibians; but in all probability reptiles sprang into existence at the close of the Carboniferous. The amphibians were of unusual size and were the kings of land life during this period.

The vegetable kingdom had advanced equally as rapidly as had the animal. The small forests of the Devonian merged into large ones during the lower Carboniferous and these into great jungles and vast forests during the upper Carboniferous. The last was the first great coal-making period, during which the great coal fields of central and eastern United States, England and many other countries were deposited. Conditions favored the rankest growth of vegetation at that time, which accumulated in the marshes where it had grown and was afterwards buried beneath the rocks and changed to coal. All of the trees of this period were lower types than the deciduous trees; many of them were similar to the ferns of our day. For example, the scouring rushes that grow along our

PLATE III.



SOME CARBONIFEROUS FOSSILS.

[Explanation of Plate III.]

No. 1—*Myalina subquadrata,* Shumard.
No. 2—*Chonetes granulifera,* Owen.
No. 3—*Aviculopectin occidentalis,* Shumard.
No. 4—*Zaphrentis stanburyi,* Hall. One-half natural size.
No. 5—*Productus nevadensis,* Meek.
No. 6—*Seminula argentia,* Hall.
No. 7—*Spirifernia pulchra,* Meek.
No. 7*a*—Side view of No. 7.
No. 8—*Goniatites goniolobus,* Meek.
No. 9—*Orthis resupinata,* Martin.
No. 10—*Productus longispinus,* Sowerby.

streams and are seldom over 18 inches or 2 feet in length, and a quarter of an inch in diameter, were large trees during the Carboniferous coal period. Besides the great accumulation of coal in the Carboniferous, there were beds of iron ore, fire clay as well as other clays, gypsum, salt, petroleum and gas. Petroleum is never found associated with coal veins. There are also deposits of lead and zinc ores in the lower Carboniferous of the Mississippi valley. In Wyoming the Carboniferous rocks in no way compare to the series in the east. They do not contain any coal, clay, salt beds, gypsum, lead or zinc, nor do they contain either oil or gas. The only valuable economic products thus far discovered have been iron and copper ore, together with building material. The great iron deposits at Rawlins and Hartville are found in these rocks, as are oxidized copper ores in the same regions. In a few localities there are beds of marble and marble onyx.

Since these rocks occur in every artesian basin in Wyoming and are thicker than any of the preceding formations, they are worthy of special consideration. In southeastern Wyoming the best wells will be found in these strata, and to the northward they will always be found to contain very valuable water bands. As a general rule water will be found at less depth than in the earlier formations. Especially is this true in localities where wells are to be drilled near the foot of the mountain, in the Triassic red sandstones. The supply of water will vary greatly with the localities; but as a rule it will be found very satisfactorily, and will also be excellent water for all purposes. Generally speaking, these rocks, with the Permian, form the lower slopes of nearly all of our mountain ranges.

THE PERMIAN PERIOD.

The Permian terrane is not well represented in America, and until recent years many have objected to referring any of the strata to this period. It was a usual thing for the geologists employed by Hayden to refer the highest bands of the Paleozoic of Wyoming to the Permian; but in no case did they offer any evidence for so doing. Later, no one considered any of these strata as Permian. Only a year ago I discovered along the flank of the Laramie mountains a formation, not over 200 feet in thickness, that contains a fauna almost the same as has been reported from the Kansas and Nebraska Permian. There seems little reason to doubt that these rocks are widely distributed and are to be found in the Big Horn and Wind River ranges, as well as in the southeastern corner of the state. The strata along the Laramie mountains are composed of light colored limestones, pink calcareous sandstones, light red sandstones and a bed of pure white sand that has been utilized for glass-making. It is possible that the rocks that have been assigned to the Upper Coal Measures may prove to be Permian. The presence of copper in the bands points that way.

During the Permian period of the world, the life resembled the Carboniferous. There were many lingering Coal Measure genera and a few species. There were also fossils that took on Mesozoic characteristics. The vertebrate life was not only represented by fishes and amphibians, but also by the introduction of reptiles.

The close of the Paleozoic was a mountain-making period and the Appalachian and many foreign ranges were made. In Wyoming there was no change or folding of the strata, and the great Paleozoic era passed into the Mesozoic era as uninterrupted as in many other instances one stage passed into another. Where Permian rocks are definitely known in Wyoming they all form the lower slopes of the mountain ranges and occasionally extend well up to the Archæan. Of the Paleozoic, these beds are of the least importance in the artesian basins. They are, however, superior to any of the Mesozoic.

Usually it will be possible to start a well in the Dakota sandstones, and pass through the Jurassic and Triassic and secure water in the Permian.

The Mesozoic Era.

Wyoming was a land mass during the greater portion of the Paleozoic era, and this accounts for the extremely thin beds of rock belonging to that grand division of geological time. At the close of the Paleozoic era, in the eastern part of the United States, the Appalachian mountains were made; but in Wyoming the Paleozoic seas merged into the Mesozoic without any interruptions, which causes the Mesozoic to rest upon the Paleozoic apparently conformably. It is very thick, from 20,000 to 30,000 feet. They differ from the older rocks in being less compact, and also in containing numerous bands of shale and clay. Although very thick, there are only a few bands containing limestone. Conditions had so changed that the seas were shallow and in some instances fresh water lakes covered vast areas. The changes in life were very important. In the early Mesozoic the vertebrate life had so advanced on earth that huge reptiles occupied both land and sea. The swimming saurians are known as *Plesiosaurs* and *Ichthyosaurs;* the land reptiles as *Dinosaurs.* Mammalian life was also introduced about this time: but the animals were about the size of a mouse and belonged to the lowest type. Our modern fishes also appeared during the early Mesozoic. Toward the middle of the Mesozoic, flying Saurians appeared, and also birds. It was about this time that the *Dinosaurs* reached their maximum development. Vegetable life was also advancing and in the upper portion of the era the first deciduous trees appeared on earth. At the close all of the

Plesiosaurs, Ichthyosaurs, as well as many other kinds of swimming Saurians, together with the *Dinosaurs* and *Pterosaurs* (or flying Saurians), became extinct. These rocks at one time covered nearly all of the state, and although great mountains have been made and hundreds of square miles of rock have been carried away by erosion, they cover or underlie three-fourths of Wyoming at the present time. They are found as the base of the mountains and occupying the valleys and forming the plateaus. They play an important part in the artesian basins of the state, since they are associated with all of them. At the close of the Mesozoic, the Rocky mountains were made and the mountain system that practically extends from Tierra del Fuego to Alaska came into existence.

THE TRIASSIC PERIOD.

This series has been called by other names than Trias, or Triassic. In the old world they are known as the "New Red Sandstone" and in Wyoming they have been called the "Red Beds." Of all the geological formations in Wyoming, this is the most conspicuous. It has numerous beds of dark red sandstone, with some red shales and thick beds of gypsum near the base. These bands can be seen at the foot of nearly all of the mountain ranges, either forming precipitous bluffs that rise a hundred or more feet, facing the range, or in dark red bands, following its trend. In some localities they have been nearly leveled by erosion, but can be seen cropping out at the crossing of every stream and in the red soil caused by their decomposition. They often color a wide band reddish that winds about the foot of the mountain like a great snake. Quite frequently these rocks are wind worn and cut into the most fantastic forms and are not easily surpassed for natural artistic beauty. In other regions there are deep circular depressions caused by caves in the Permian rocks below. This makes circular caves which are often one hundred feet in diameter and sometimes a hundred or more feet deep. These depressions are common in Crook county, east of Sundance, and near Spring creek, Big Horn county. Forming as this period does the base of the Mesozoic, they can easily be separated from the light colored sand and limestones of the Permian below, and the dark colored fossiliferous bands of the Jurassic above. No fossils have been recognized as in other sections, and the entire series is barren or nearly so, for not a single species of fossil of any kind has been reported from them. In other parts of the United States, and in Europe, they are rich in both plant and animal life and are especially marked by the introduction of swimming Saurians and mammals. The mammals were very small, probably not larger than a good-sized mouse. Good, and frequently bad, water will be found in the Triassic sandstones. The usual impurity is gypsum, which makes the water extremely hard and slightly bitter. While it is usually called poor water, it is nevertheless valuable for irrigation purposes. These sandstones will always furnish water in all of the artesian basins, but no one should expect to find a supply such as might be obtained in the Paleozoic rocks.

THE JURASSIC PERIOD.

Formely the Jurassic and Triassic terranes were united for the Rocky mountains under the head Jura-Trias. They are, however, so different in their general characteristics that a novice can easily draw the line of demarkation, and there is no reason why they should not be discussed as they are here, under different heads.

The Jurassic rocks are everywhere found resting upon the Triassic red sandstone, and are widely distributed throughout Wyoming. Of this series there are two distinct stages, the Shirley representing the marine and the Como the fresh water or upper division.

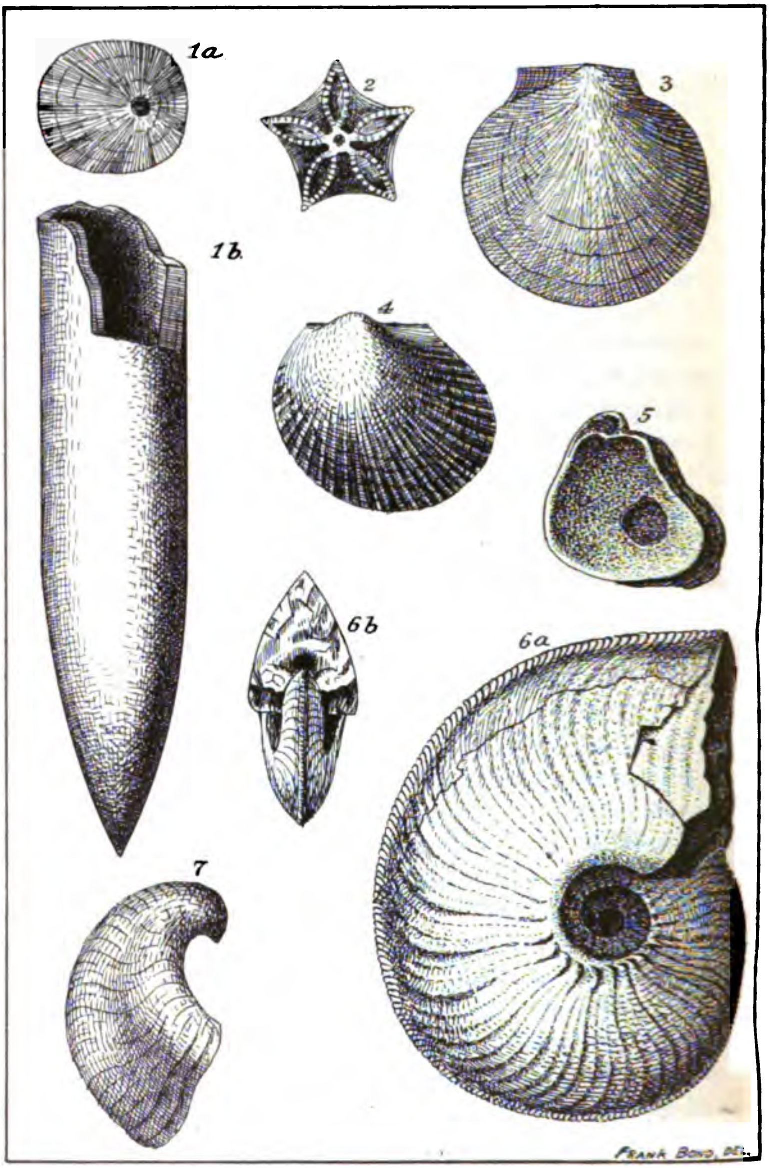
These stages represent a very small portion of the Jurassic time and should be considered as belonging to the upper third of the Jurassic rocks. In reality they represent only a fraction of this division.

THE SHIRLEY STAGE.

The Shirley stage is composed of bands of dark clays and shales, together with a few thin bands of dark colored limestones and numerous strata of sandstone. Near the base the sandstones are usually light colored. In thickness this stage varies from a few feet to 250 feet and probably exceeds this in the western part of Wyoming. In southeastern Wyoming this formation does not occur, the limit being between twenty-five and thirty miles northwest of Laramie. With the exception of southeastern Wyoming, the Shirley rests upon the Triassic, and often the light colored sandstones are found in contact with the red.

There is a single characteristic fossil that always accompanies these beds and it is scientifically known as a *Belemnite.* It is a rather slender fossil, circular in traverse section, and tapering gradually to a point. Sometimes there is a conical opening at the broad end, and in fact there always is when the fossil is complete. A large one is six inches long and three-fourths of an inch in diameter. Besides the *Belemnites* there were numerous invertebrates and swimming Saurians. The *Ichthyosaur* or fish Saurian was a reptile with a long, large head, no neck, a round body with four paddles, and a long, slim tail. They varied in length from 12 to 40 feet and were very ferocious animals, that subsisted entirely upon flesh. Associated with the *Ichthyosaurs* were many other types of swimming reptiles, chief of which were the *Plesiosaurs,* or Plesiosaur-like animals. These differed from the foregoing in having long necks and larger paddles. They attained a greater length and were also carnivorous in habit, and absolute rulers of the sea. The largest of the Plesiosaur type known was discovered in Wyoming. A front paddle in the University

PLATE IV.



FRANK BOND, DEL.

SOME JURASSIC FOSSILS FROM THE SHIRLEY STAGE.

[Explanation of Plate IV.]

No. 1*a*—*Belemnites densus,* Meek. Side view.

No. 1*b*—Transverse section of No. 1*a*.

No. 2—*Pentacrinus asteriscus,* Meek. Enlarged.

No. 3—*Camptonectes bellistriata,* Meek. One-half natural size.

No. 4—*Pseudomonotis curta,* Hall.

No. 5—*Ostrea strigilecula,* White.

No. 6*a*—*Cordioceras cordiformis,* M. & H. Much reduced. Side view.

No. 6*b*—*Cordioceras cordiformis,* M. & H. Much reduced. Profile view.

No. 7—*Gryphaea calceola,* var. *nebrascensis,* M. &. H. One-half natural size.

collection is nearly eight feet in length, and other parts in proportion. Associated with the land life, which was largely *Dinosaurs,* were numerous *Pterosaurs,* or flying reptiles, and a few birds that were provided with teeth. None of these have been found in Wyoming, but are associated with Jurassic rocks in other regions. In these seas there were also numerous fishes and turtles, and along the rivers many crocodiles.

THE COMO STAGE.

The Como stage at one time covered the entire state with one possible exception, and persists at the present, except in localities where mountain-making and folding have caused excessive erosion. These strata differ from the Shirley in being of fresh water origin, and hence they do not contain any marine life. This character alone will aid any one in separating them from the lower beds. The formation is from 150 to 250 feet in thickness, and above it there is nearly always a band of either Dakota conglomerate or sandstone, of the Cretaceous. It is a common thing to see the slopes of the Como, which are often quite precipitous, piled up with blocks of Dakota conglomerate, which range from a few feet to cubes 20 feet in diameter. The strata are largely marls and clays of different colors, with yellow, brown, red and drab predominating. These are separated by a few thin bands of sandstone and limestone.

The Como stage is the great *Dinosaur* horizon from which the many curious and huge animals have been collected. *Dinosaurs* represent the largest land animals that have ever lived, as well as very small ones. Wyoming is justly celebrated for these remains, since there is not another spot on earth where so many have been found. The largest of these animals were 80 to 90 feet in length and stood 20 to 25 feet high. A thigh bone in the University collection measures 69 inches high and the shaft is 33 inches in circumference.

A dorsal vertebra is 40 inches high and the centrum measures 12 inches in diameter. A rib is nearly seven feet long and is 14 inches in circumference.

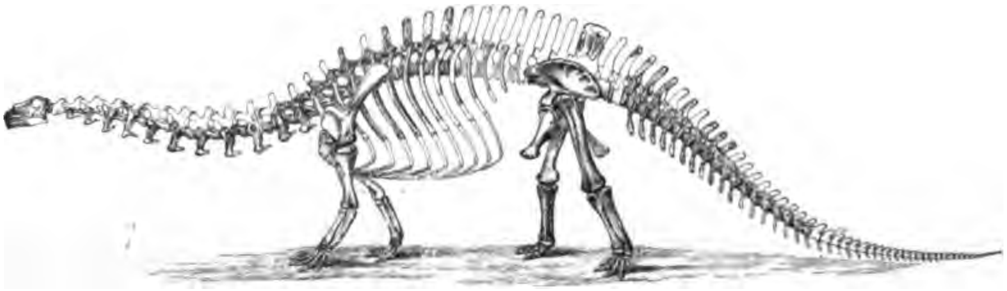
The largest animals were herbivorous quadrupeds; but others, which hopped about like a kangaroo, were carnivorous. Some had huge plates of bone ornamented with spikes; in fact, the life was too varied to even notice in a description of this sort. The bones of these animals are found in beds of marls and sanstones and sometimes occur in layers that are four feeet thick, and so mixed up that the most expert anatomist can not assemple them again.

With the marl beds there occur fresh water mollusks, some fishes and crocodiles. But little is known of the vegetable life. There are numerous species of petrified wood found and also some Cycad trunks. Cycads were an early form of vegetable life, the trunk of which grew about a foot in height and from six to ten inches in diameter. They are conical in form and are marked in the surface with many diamond-shaped leaf scars. Some twenty species have been found in the Como stage.

During this stage Wyoming was a low, marshy country, largely covered with fresh water lakes, about which grew a tropical vegetation. From an artesian standpoint this formation is of less importance than any of those previously discussed.

The marls and clays contain considerable sodium sulphate, which is often seen as a thin, efflorescent crust on the surface. Good water follows the sandstones, especially the light colored bands. Great precaution should be taken in drilling through the Jurassic, for the strata of clay and marls will produce caving of a very serious nature. The Jurassic, taken as a whole, will be encountered in drilling in every basin in Wyoming in case the well is located in the Dakota stage and is drilled to a depth of 1,000 feet or more.

PLATE V.



Brontosaurus excelsus, after Marsh. This animal, when alive, was 80 or 90 feet in length and lived in Wyoming during the Como stage of the Jurassic.

THE CRETACEOUS PERIOD.

The Cretaceous rocks of Wyoming belong to the upper half of the period, with the possible exception of some thin bands found in northern Wyoming, which may be lower Cretaceous. This is the greatest system of rocks of the state, for they cover or underlie over 50,000 square miles of territory. Taken as a whole, the stages are chiefly made up of sandstone, shales and clays, which reach the enormous thickness of from 20,000 to 25,000 feeet. The Cretaceous is to Wyoming what the Carboniferous is to Pennsylvania, if considered from an economical standpoint, for these rocks contain all of the coal known in the state and nearly all of the petroleum and natural gas.

Hayden studied the western Cretaceous along the Missouri river nearly half a century ago and made the following divisions:

	Thickness given.
Fox Hills	500 feet
Fort Pierre	700 "
Niobrara	200 "
Fort Benton	800 "
Dakota	400 "

Since these names were adopted there have been many changes in the meaning of some of them, and the introduction of new terms to take their places. For example, some of the geologists have included the Niobrara, Fort Pierre and Fox Hills under the name Fox Hills. Others have used Fort Pierre to represent the same band. The United States Geological survey have included the Fox Hills and Fort Pierre under the name Montana and the Fort Benton and Niobrara under the name Colorado, but retaining the original names given by Hayden, for lesser divisions. Following the work of Hayden along the Missouri river was the mountain investigation, and the Laramie stage was discovered. At present the Cretaceous divisions are as follows:

		Estimated Thickness. Maximum, in feet.
Laramie...	Fort Union?	2,000
	Laramie	5,000
Montana..	Fox Hills	6,000
	Fort Pierre	7,000
Colorado..	Niobrara	2,000
	Fort Benton	2,000
Bear River		3,500
Dakota ...		1,000?

These stages, so far as known, are conformable with each other.

The geological history of the accumulation of this great series of rocks is intensely interesting, but can not be given in this connection.

Following the Jurassic, when the greatest Saurians lived, we find Saurians, and especially *Dinosaurs,* up to the close of the Laramie. The swimming Saurians, *Plesiosaurs* and *Mososaurs,* were also common; but disappeared from the face of the earth prior to the close of the Cretaceous. Birds that were introduced in the Jurassic became quite numerous in the Cretaceous; but the mammals made no advance. Plant life was very abundant, as the many bands of sandstone and shale containing impressions of leaves, as well as the numerous coal veins, demonstrate.

The invertebrate life was represented by numerous species which resembled the shell fish of today much more than the fauna of the Carboniferous period. The Cretaceous period of Wyoming opened under fresh-water lake conditions and closed in a similar manner, the lake being mostly fresh water but occasionally brackish at the close. Nearly all of Wyoming was originally covered with Cretaceous rocks during the coal-making period. Then dawned the period of mountain-making, which caused these strata, together with the underlying ones, to be bent into great folds, which are now the axes of our mountain ranges. During this period Wyoming was changed from a nearly level country, that was about sea level, to one of great mountains and valleys. Originally all of the prominent ranges were covered with from 10,000 to 30,000 feet of sedimentary rocks, which have been removed by erosion. The Cretaceous rocks are to be found encircling the mountain ranges and lesser folds. At one time they occupied the great valleys, as for example the Green river, Big Horn river, Wind river, Powder river, Platte river and Laramie river. In the Green, Wind and Big Horn basins large areas are covered with Tertiary sediment. Although the Cretaceous strata are so extensive, and very thick, they do not play a very important part in the artesian basins as water-bearing rocks. The Dakota will in all probability be the most desirable water-bearing zone, and from this upwards in the geological scale the bands gradually become of less importance. The stages will be taken up under their respective heads and their strata discussed.

THE DAKOTA STAGE.

Until recent years this has been considered the base of the Upper Cretaceous, but since the investigations of Dr. Ward in the Black Hills it has been separated into two stages, one representing the lowest member of the Upper Cretaceous and the other the highest horizon of the Lower Crectaceous. Since this distinction has not been worked out in Wyoming, it will be considered under the original meaning. The upper half of the Wyoming Dakota is made up of bands of dark clays and shales and a few thin layers of gray sandstone; the lower half of thick beds of conglomerate and sandstone. On the slopes below the beds there are angular blocks of conglomerate which usually rest in the Como stage, which vary from a few feet to twenty feet in diameter. The thickness of this stage varies considerable, but is never less than 200 feet and has local developments varying from 500 to 800 feet and possibly more Few fossils* have been reported from the Wy-

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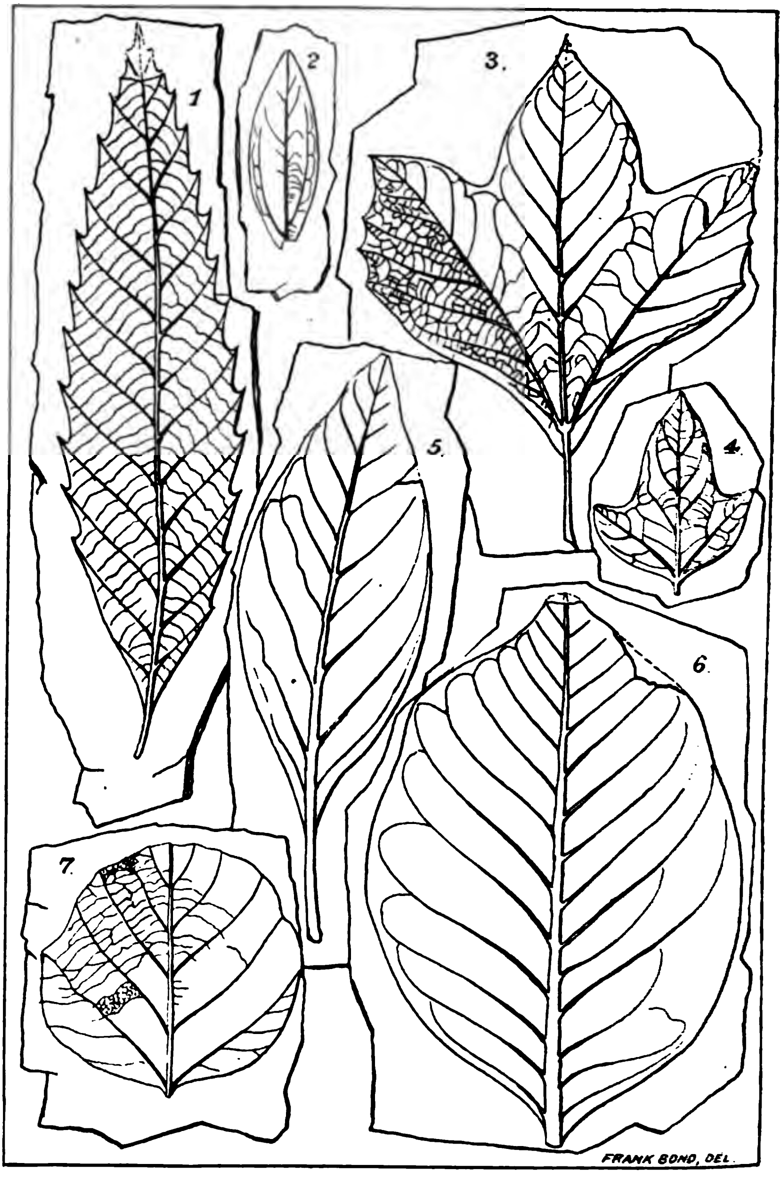
*Since writing the above I have found in the sandstones of the Dakota, in Johnson county, a small pelecypod, probably belonging to the genus *Nucula*.

PLATE VI.



CRETACEOUS.

SOME LARAMIE FOSSIL PLANTS.

[Explanation of Plate VI.]

No. 1—*Quercus primoidalis,* Lesqx.
No. 2—*Cinnamomum scheuchzeri,* Heer. One-half natural size.
No. 3—*Sassafras cretaceum,* Lesqx.
No. 4—*Sassafras mudgei,* Lesqx. One-half natural size.
No. 5—*Platanus recurvata,* Lesqx.
No. 6—*Juglans debeyana,* Lesqx.
No. 7—*Populites cyclophilla,* Heer? One-half natural size.

oming rocks and these have been found about the Black Hills in Wyoming, and are all plants. In these rocks are found the first evidence of deciduous trees in Wyoming. The formation can best be determined by its lithological character and its position in reference to the Como stage of the Jurassic and the overlying Fort Benton shales. This is the great water bearing horizon of the Dakota artesian basins and is also a conspicuous water horizon throughout Wyoming. Springs of excellent water are of common occurrence in these rocks along the mountains. Some attention should be paid to the fact that this is the second great petroleum horizon in Wyoming and that it also contains valuable veins of coal in Weston, Crook and Big Horn counties, and probably in many others. Along the Rattlensake, Powder River, Dutton, Belle Fourche, Bonanza and Beaver oil basins the Dakota will contain inferior water unless it is found in some of the upper sandstones above the oil. The rocks of this stage were deposited in fresh or brackish water.

BEAR RIVER STAGE.

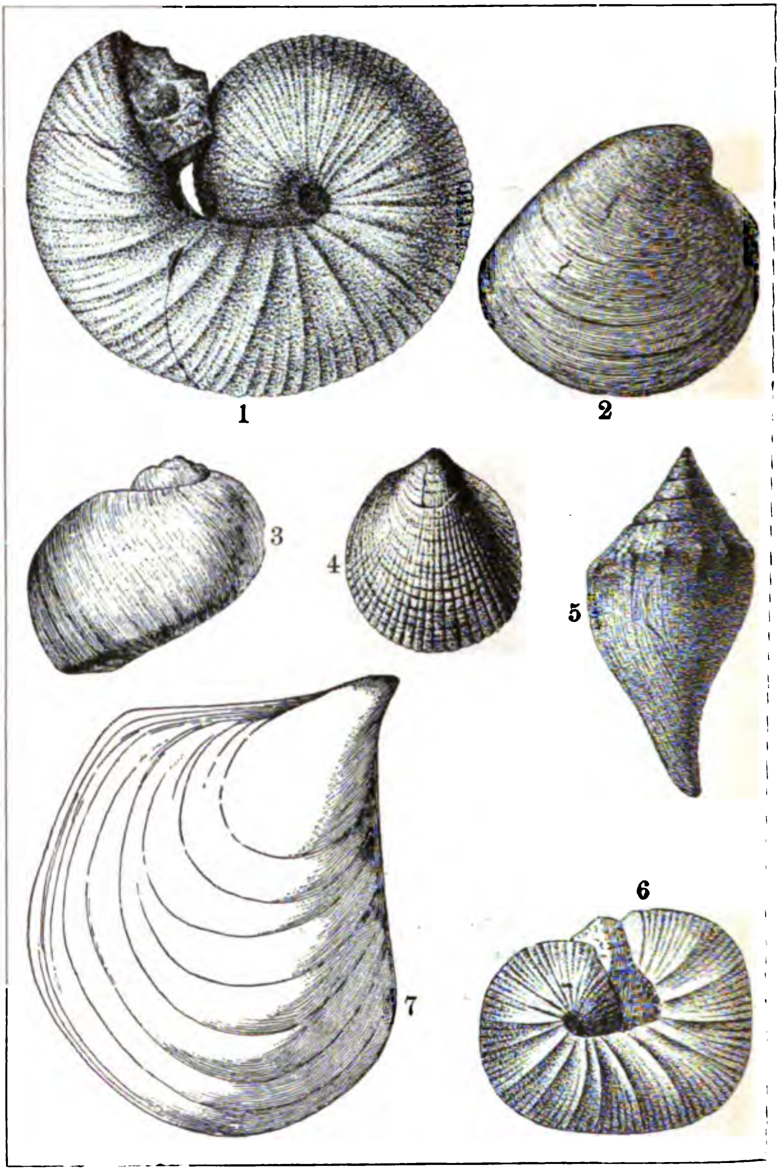
In southwestern Wyoming there is a formation that appears to be between the Dakota and the Fort Benton. It is characterized by an independent fauna and is coal bearing. It has been named the Bear River stage by the U. S. G. S. and it seems very probable that it is a distinct stage and should be included with the others of the Cretaceous. Some authors consider it a division of the Fort Benton. It has been found only in the southwestern part of the state and does not play an important part in our geology.

FORT BENTON STAGE.

Resting conformably, or nearly so, upon the Dakota of the eastern portion of Wyoming, is the Fort Benton. In the western half of the state the eastern limit of the Bear River has not been worked out, so that the Fort Benton can be considered as resting upon either the Dakota or Bear River stage. At the base of the Fort Benton there is always formed a very thick band of dark colored fissile shales, which weather nearly white. These shale beds are usually 200 feet in thickness, and if they are highly inclined the slopes are always covered with fragments of the shale bands. Associated with these beds there are numerous impressions of fish scales, a few mollusks, and a few fish teeth. Above the shales there are prominent beds of dark clays and some shale bands that are nearly black, which are often mistaken for coal shales by eastern coal miners. In the dark clays there are masses of clay-iron stone that are nearly continuous, but not thick enough to be of commercial importance. In these clays are a few bands of Bentonite (a clay that has been called natural soap) which is destined to become a very important article of commerce. This clay is a hydrous, non-plastic variety which has an unusual power as an absorbent. The upper third of this stage is composed of sandstones and clays. The sandstones are usually of a light brown color and contain numerous fossil mollusks and sharks' teeth. The Fort Benton has a maximum thickness of at least 2,000 feet. Oil springs and natural gas vents have been found in several localities. As a water-bearing horizon it is very questionable. The clay beds contain an unusual amount of the sulphates of sodium and magnesium, and drilling will be found difficult on account of so many soft bands. The water supply will not be large. The upper half of the stage, when the sandstone bands are most numerous, will furnish the best water.

Typical exposures of the Fort Benton shale can be seen at the following localities: North of Hutton's lake, Albany county; at Brown's canon and Freezeout hills, Carbon county; a few miles east of Lander, in Fremont county; at Bonanza and

PLATE VII.



CRETACEOUS.

FORT BENTON FOSSILS.

[Explanation of Plate VII.]

These fossils are conditionally placed under the Fort Benton stage; realizing that the line between the Fort Benton and the Niobrara has not been finally fixed, and until this has been done we cannot say definitely what are Fort Benton and what are Niobrara fossils.

No. 1—*Scaphites ventricosus,* M. & H.
No. 2—*Cyrena securis,* Meek.
No. 3—*Gyrodes depressa,* Meek.
No. 4—*Cardium pauperculum,* Meek.
No. 5—*Fasciolaria (Crytorhyhis) utahensis,* Meek.
No. 6—*Scaphites warreni,* M. & H.
No. 7—*Inoceramus fragilis,* H. & M.

two miles west of Cody, Big Horn county; southwest of Dayton a mile or so, in Sheridan county; at the Belle Fourche oil field, in Crook county; at Newcastle, in Weston county; along the north side of the Laramie mountains, in Natrona and Converse counties, and along the east side of the same range in Laramie county.

THE NIOBRARA STAGE.

We know less of the rocks of this stage than any other one of prominence in Wyoming. This is due to the nature of the strata, which in the southeastern part of the state have near their base a thick bed of yellowish-white chalk. This has yielded so readily to erosion that it is seldom seen outcropping. For miles along the foot of a mountain range the chalk beds have been entirely covered with soil. The thickness of this stage approximates 2,000 feet. When the chalk beds are exposed it can be considered sufficient evidence of the stage, for there are no other beds of chalk known in Wyoming. In the Tertiaries there are whitish, soft bands that have been called chalk, such as the many chalk bluffs, hills and mountains; but none of these are chalk and some of them do not contain any carbonate of lime. Above the chalk beds the strata are clays and shales chiefly, with a few bands of sandstone. None of these bands contain many fossils, and all that have been reported are invertebrates. In Kansas they contain great swimming Saurians *(Plesiosaurs* and *Mososaurs)* and also early birds that were provided with teeth. So far, in the development of the mineral resources of the state, nothing of economic importance has been discovered in the Niobrara. There are a few beds of oil sand, and these together with the clays, shales and chalk beds, will prove to be of value in the future.

This stage is on a par with the Fort Benton, so far as artesian wells are concerned. Good water will be found in the sandstones and chalks, but the clays and shales contain a vast quantity of soluble salts that will render the water unfit for any purpose. While flowing wells will be found, the amount of water from any of the bands will not be large.

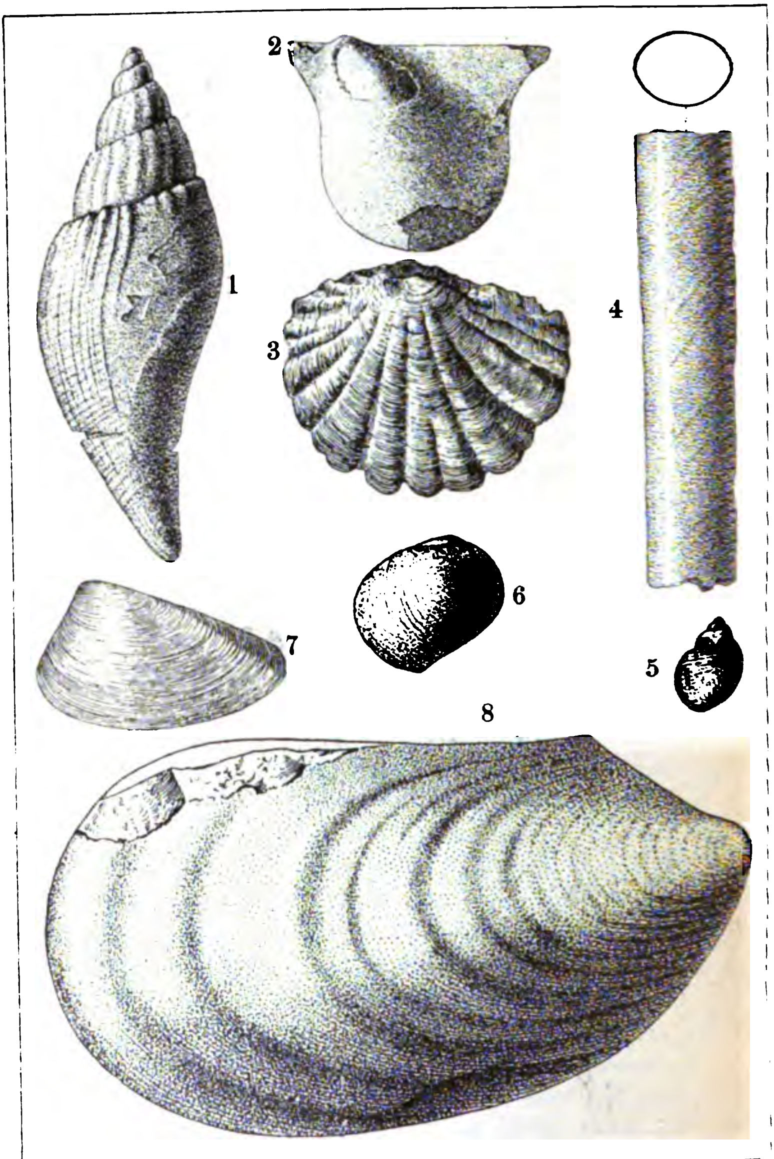
THE FORT PIERRE STAGE.

This is the thickest formation of the Rocky Mountain Cretaceous, having a maximum thickness of over 7,000 feet. It has been found along all of the Wyoming mountain ranges. The rocks of this stage are chiefly dark colored shales, which contain a few fossils, especially *Baculites.* The shales are in the lower half of the series and gradually change toward the top to bands of sandstone and clay. Near the top there are several bands of very fossiliferous sandstone. Besides the bands of sandstone there are strata made up of concretions of various sizes, ranging from a few inches to ten feet in diameter. Some of these concretions have been formed about a mass of invertebrates and when broken open contain specimens that have retained their irridescent luster and are the most beautiful of all Cretaceous fossils. While these concretions can be considered a valuable indication of the Fort Pierre, their presence can not be taken as absolute testimony, since there are concretions found in other Cretaceous stages. A few typical fossils associated with the concretions would furnish ample means for determining this stage.

The fossils associated with the Fort Pierre are numerous. There were many vertebrate animals, but few of these have been found in Wyoming. In the upper bands of sandstone there are many species of fossil plants. The invertebrate fossils, which are of greatest importance in identifying these rocks, are species of *Baculites, Inoceramus.*

Economically these strata are of considerable importance. Petroleum has been found in a few instances and probably the Salt Creek oil occurs in this stage. Coal has also been reported, but it is not definitely known that there are workable

PLATE VIII.



CRETACEOUS.

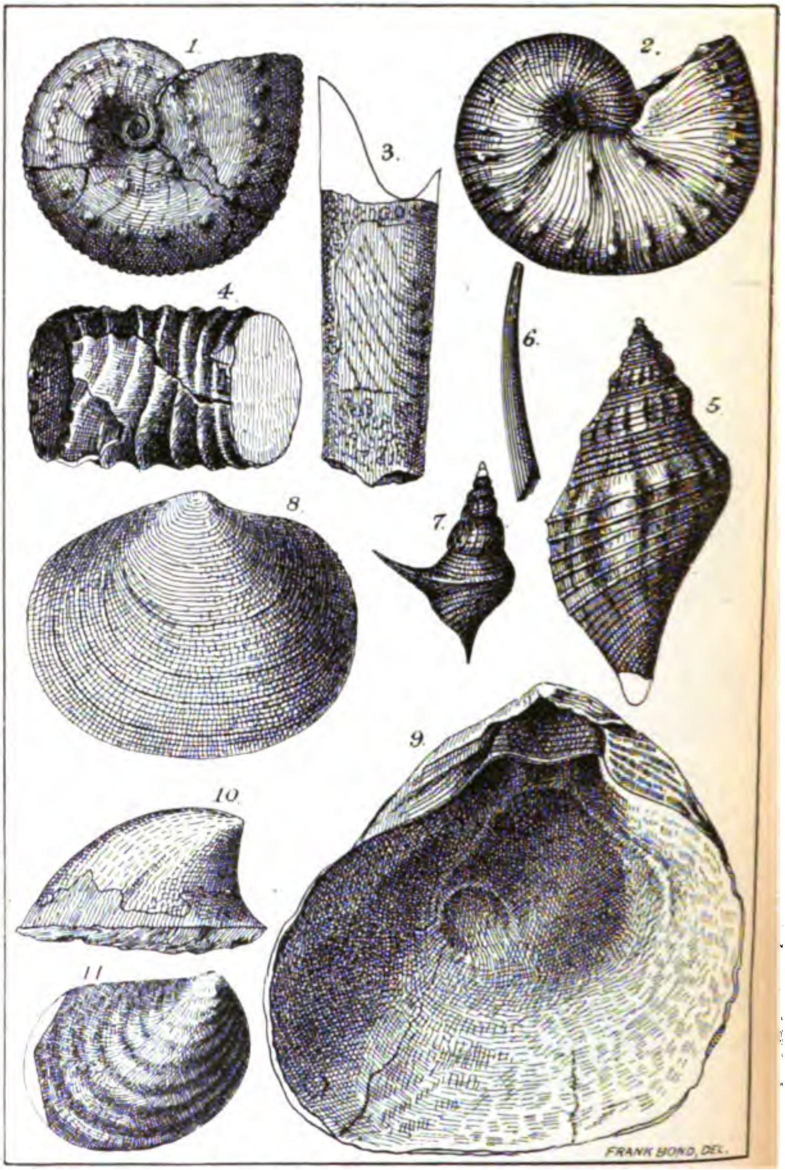
NIOBRARA FOSSILS.

[Explanation of Plate VIII.]

These fossils are conditionally referred to the Niobrara stage. Eventually they may be found to belong in part to the Fort Benton.

No. 1—*Rostellites ambigua,* Stanton.
No. 2—*Avicula gastrodes,* Meek.
No. 3—*Ostrea lugubris,* Conrad.
No. 4—*Baculites gracilis,* Schumard?
No. 5—*Lunatia concinna,* H. & M.?
No. 6—*Neritina pisum,* Meek.
No. 7—*Corbula sutrigonalis,* M. & H.
No. 8—*Inoceramus labiatus,* Schloth.

PLATE IX.



CRETACEOUS.

SOME FORT PIERRE FOSSILS.

[Explanation of Plate IX.]

No. 1—*Placenticeras placenta,* var. *intercalaris,* M. & H. One-fourth natural size.

No. 2—*Scaphites nodosus,* var. *brevis,* M. &. H. One-half natural size.

No. 3—*Baculites ovatus,* Say. Much reduced.

No. 4—*Heteroceras angulatum,* M. & H. From a fragment. One-half natural size.

No. 5—*Pyrifusus intertexus,* M. & H.

No. 6—*Dentalium gracile,* M. & H.

No. 7—*Anchuria nebrascensis,* E. & S.

No. 8—*Lucina occidentalis,* Morton.

No. 9—*Ostrea patina,* M. & H.

No. 10—*Anisomyon borealis,* M. & H.

No. 11—*Inoceramus cripsi,* var. *barabini,* Morton.

veins. Clay beds are very numerous, and all grades of clay are found, varying from that used for common brick to the best fire-brick clays.

On account of the enormous thickness of these strata, the formation is usually found in broads bands at the foot of the mountains. The sandstone strata alternating with bands of clay make the artesian conditions ideal, but the pressure will usually be found to be very slight. For this reason the Fort Pierre can not be considered as an important artesian well horizon. Again, the quality of the water is questionable. The shales contain vast quantities of soluble salts which in many instances make the water unfit for any use. Good water usually accompanies the sandstone unless found in the vicinity of coal and oil.

Typical Fort Pierre exposures can be seen north of Harpers, in Albany county; where the Cheyenne and Northern railroad crosses Horse creek, Laramie county; a few miles north of Ervay, Natrona county; west and south of Lander, west of Bonanza, and between Sheridan and the Big Horn mountains.

THE FOX HILL STAGE.

The Fox Hill and Fort Pierre stages are often combined under the name of Montana, but since these stages combined have a thickness of at least 12,000 feet, the terms Fox Hills and Fort Pierre include too great a thickness for a single stage and as soon as they are thoroughly known they will be further subdivided. The Fox Hills in Wyoming has a thickness of 5,000 feet, and probably there are local developments that will reach 6,000 feet. The strata resemble the upper portion of the Fort Pierre and are mostly bands of brown sandstone, alternating with dark clays and shales. Usually there are a few hundred feet of light colored sandstones near the base, and a very thick band of brown sandstone capping the formation. The sandstones are very fossiliferous and contain remains of vertebrates, invertebrates and plants. It was in this stage that the *Plesiosaurs* became extinct. The fossil leaves are quite remarkable. In the white sandstones near Harpers palm leaves have been discovered that have a diameter of twenty inches. The invertebrates resemble to a marked degree the Fort Pierre, but there is a sufficient difference to distinguish one stage from the other. The most common vertebrate fossils are species of *Baculites, Inoceramus, Ostrea, Anchuria, Scaphites, Nautilus* and *Pectunculus.*

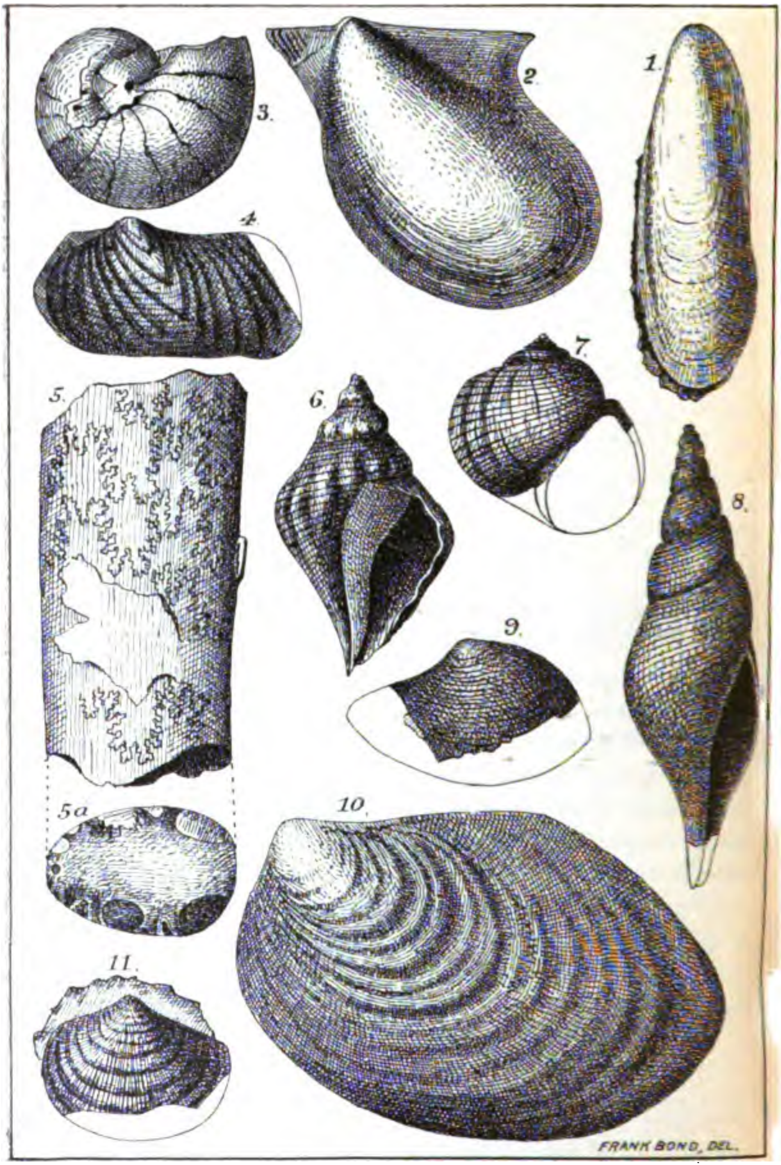
Economically this stage produces coal, oil, clay and building stone. Very valuable coal veins occur at Kemmerer, Diamondville and on the Laramie Plains and at several other points. Petroleum has been found in the Fox Hills along the Rattlesnake mountains. Typical exposures can be seen at Harpers, Kemmerer, below Bonanza, above Dayton, south of Fort Steele and at the southern base of the Seminoe mountains.

While the water found in the Fox Hills sandstones is usually superior to the Fort Pierre, yet it is not ideal. It can be relied upon as a water-bearing formation, but wells drilled in these strata will seldom yield a large supply of water. The reason for this is the same as given in the Fort Pierre—there is little or no head, and also the water supply is very limited on account of the distance from the mountains and the slight precipitation. Wells drilled in coal and oil belts may be considered as almost worthless. At Almond a well 1,000 feet deep produces water highly charged with sulphuretted hydrogen. When first drawn it is unbearable, but after standing it is used for domestic purposes and also largely for locomotive work.

THE LARAMIE STAGE.

This is the closing stage of the Cretaceous period, and is also the great coal formation of the Rocky mountain region. Owing to its wide distribution, and variations lithologically,

PLATE X.



FRANK BOND, DEL.

CRETACEOUS.

SOME FOX HILLS FOSSILS.

[Explanation of Plate X.]

No. 1—*Volsella attenuata,* M. & H.
No. 2—*Pteria linguiformis,* var. *subgibbosa,* M. & H.
No. 3—*Nautilus dekayi,* Morton.
No. 4—*Goniomya americana,* M. & H.
No. 5—*Baculites ovatus,* Say. Much reduced.
No. 6—*Cinuli concinanna,* H. & M.
No. 7—*Vanikoropsis tuomeyana,* M. & H.
No. 8—*Fasciolaria culbertsoni,* M. & H.
No. 9—*Tancredia americana,* M. & H.
No. 10—*Inoceramus cripsii,* var. *subcompressus,* M. & H.
No. 11—*Liopistha (Cymella) undata,* M. & H.

this vast accumulation of sediment, which is about one mile in thickness, has not been satisfactorily subdivided into lesser divisions. This will be done when the stage has been thoroughly worked over. At present it will be sufficient to suggest that there are upper and lower divisions, the upper, probably equivalent to the Fort Union[*] stage of early writers, containing the lignite coal veins, and the lower containing bituminous coal, as can be seen at the coal mines at Rock Springs and elsewhere. The strata of the entire stage are made up of sandstones, clays, shales and coal. The sandstones are usually friable, often thick bedded, and vary in color from light gray to dark brown. The clays are in great variety and are usually of a drab color. The shales are soft and friable.

Coal seams are numerous, and in some localities there are not less than 100 veins which vary in thickness from a few inches to 10, 20 and 40 feet. At Ham's Fork, Uinta county, there is a vein of coal 86 feet thick without a parting. Usually there are from six to ten workable veins in a field.

These rocks were deposited in fresh and brackish water and contain an abundance of fossils. Usually there are bands of shale or shaley sandstone associated with the coal veins that contain vast numbers of fossil deciduous leaves. There are also strata that are from six to twelve feet in thickness that are made up of oyster shells. There are also many other invertebrate fossils, especially many species of *Unio* (the common fresh water clam). With this life there are many species of land vertebrates. Chief among these were some large

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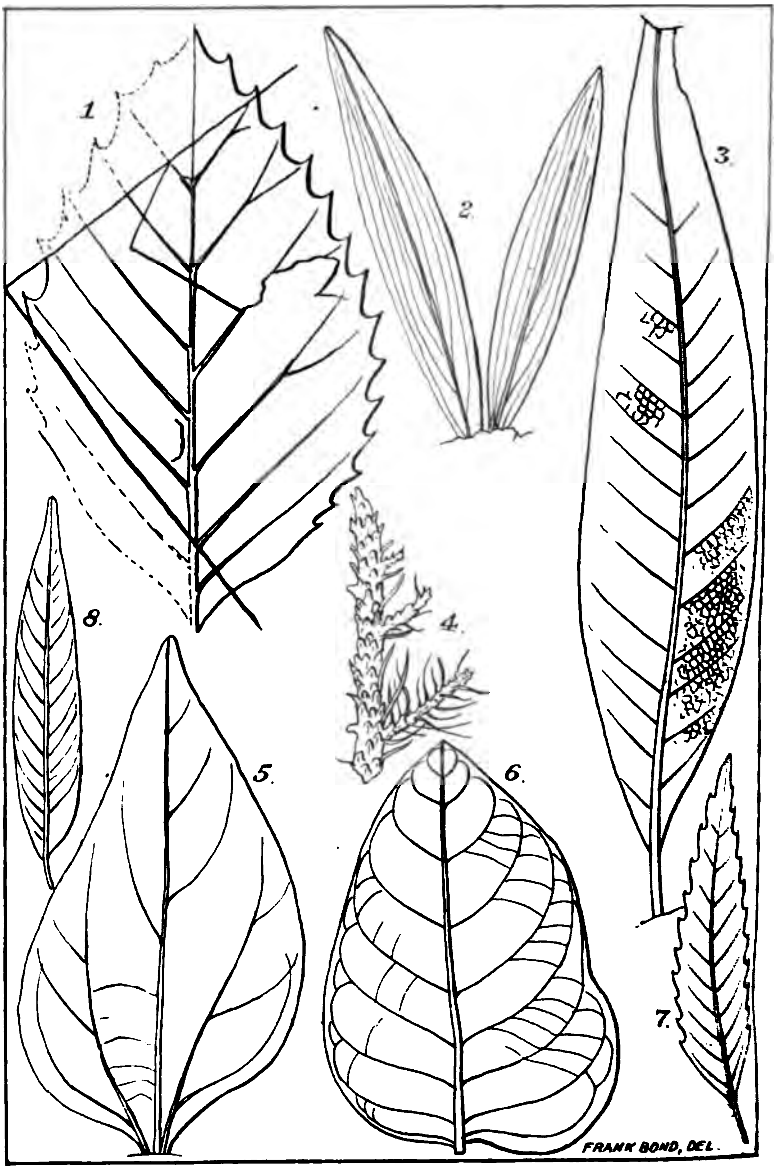
[*] Many geologists will object to my placing the Fort Union beds in the Laramie. They were so considered by many of the early geologists, who have had an opportunity to study the Fort Union formation in the field as well as to study the fossil remains. The paleobotanists have practically agreed that this formation is Eocene. I should like to see a consensus of opinions from all branches of paleontology, before this formation is finally considered to belong to the Cenozoic era. One point worthy of consideration in connection with this problem is the fact that, thus far in the study of this formation, no one has reported a mammalian fauna. It would seem that if snch exists there has already been sufficient field work done to discover it. If it ever existed during the deposition of the Fort Union sediments, there is no reason why some of the remains should not be present, for these beds are as favorable to the preservation of fossil remains as any other formation in the west. The presence of both plant and invertebrate remains is ample evidence on this point. Without the presence of a mammalian fauna, I would prefer to consider the Fort Union the highest member of the Cretaceous.

Dinosaurs. The largest one was much larger than an elephant and had a large head provided with three horns. These horns were located above the eyes and on the end of the nose. The remains of this huge creature have been found in great abundance in Converse county. There were also several other kinds of *Dinosaurs* living at this time, but they all became extinct at the close of the Laramie. There were also many species of very small mammals.

The Laramie formation is found in every county in Wyoming. The towns of Sheridan, Buffalo, Douglas, Glenrock, Carbon, Hanna, Black Buttes, Rock Springs and Meeteetse are located on these rocks. From Douglas one can go north to the Montana line and walk all the way on the Laramie coal measures. They cover nearly all of the Powder River valley, extending westward to the Big Horn mountains. The most of the coal mined in Wyoming comes from the Laramie rocks; in fact, they cover or extend beneath one-half of this state. At the close of this stage the Rocky mountains were made. Prior to this period Wyoming had been either a sea or a low land mass for geological ages; now these rocks were folded by lateral pressure and the folds soon emerged into long ranges like the Big Horn,Wind River and Medicine Bow mountains. The mountain-making caused many changes. The low swamps of the Laramie were converted into broad valleys and high mountain ranges. This change was sufficient to cause the disappearance of nearly all of the forms of life that inhabited Wyoming during the Laramie stage. It also caused a marked change in the climate, which affected the life and formed such basins as the Green River and Big Horn, which were cut off from the sea and which were, in the following stage, large fresh water lakes. The Laramie not only marks the closing of the Cretaceous system but also of the Mesozoic era.

This formation is also the last one in the ascending geo-

PLATE XI.



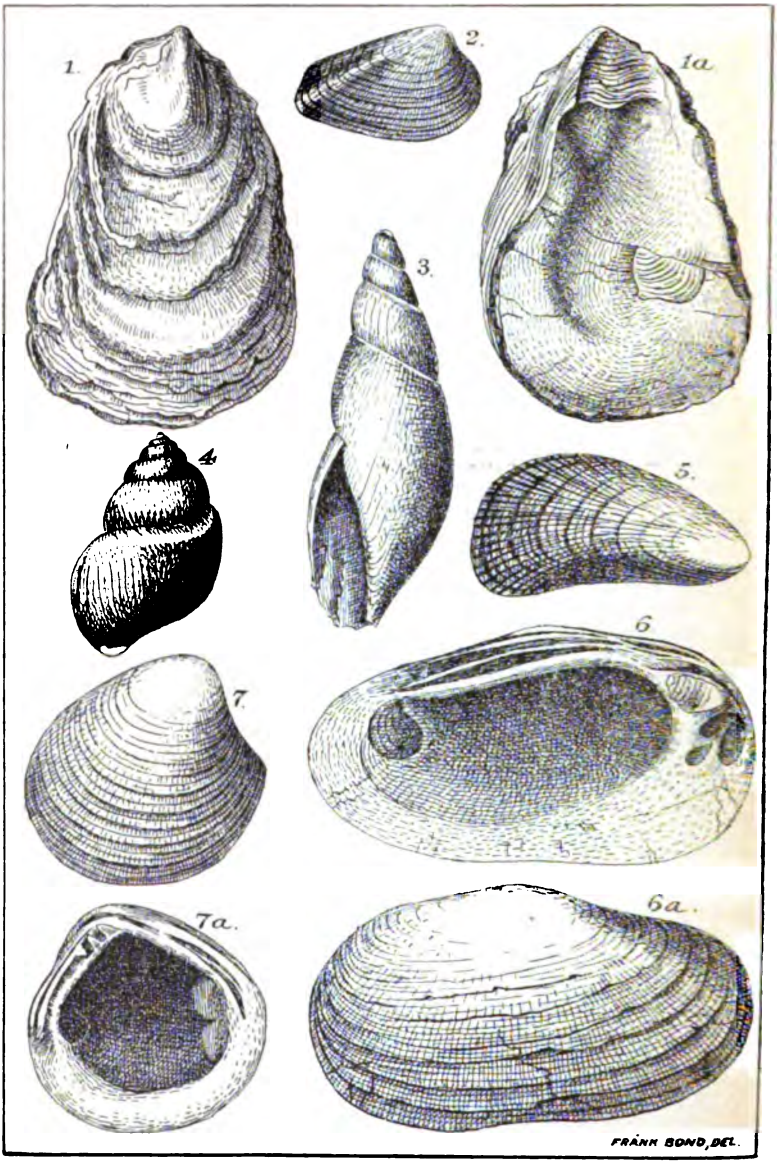
CRETACEOUS.

SOME LARAMIE FOSSIL PLANTS.

[Explanation of Plate XI.]

No. 1—*Quercus drymeja,* Ung.
No. 2—*Eucalyptus haeringiana,?* Ett.
No. 3—*Ficus lanceolata,* Heer.
No. 4—*Sequoia biformis,* Lesqx.
No. 5—*Cinnamomum affine,* Lesqx.
No. 6—*Apeibopsis discolor,* Lesqx.
No. 7—*Cillicoma microphylla?* Ett.
No. 8—*Salix angusta,* Al. Br.

PLATE XII.



SOME TYPICAL FOSSILS FROM THE LARAMIE STAGE.

[Explanation of Plate XII.]

No. 1—*Ostrea glabra,* M. & H.
No. 1*a*—*Ostrea glabra,* interior view.
No. 2—*Corbula subtrigonalis,* M. & H.
No. 3—*Bulinus atavus,* White.
No. 4—*Viviparus cousi,* White.
No. 5—*Volsella regularis,* White.
No. 6—*Unio danae,* M. & H.
No. 7—*Corbula cleburni,* White.
No. 7*a*—*Corbula cleburni,* interior view.

Note.—No. 4 on the opposite plate is in all probability a species of fresh water mollusk that belongs to the Bear River stage, but has often been referred to the Laramie. It was a mistake in placing it with the typical Laramie fossils, and should be eliminated.

logical scale in which artesian wells may be looked for, and in this the conditions are not favorable for important wells or for good water. Generally speaking, the base of the Laramie strata is a considerable distance from the mountains and the water supply is very limited. The dip of the formation along most of the ranges is slight, and there is not sufficient elevation of the lower bands to produce very much pressure. On account of the coal, all of the water coming in contact with coal veins is very poor. It is unfit for man or beast and is very often so charged with salts of soda and magnesium as to render it unfit for irrigation. Small flowing wells will be found about nearly all of the basins. Already wells have been drilled in the Laramie at numerous places and there are flowing wells at Rock Springs and Buffalo. The water at Buffalo is very good and at Rock Springs very poor.

Cenozoic Era.

After the completion of the Rocky Mountain uplift, and when the ranges were covered with sedimentary rock to a thickness varying from 10,000 to 25,000 feet, the Cenozoic era dawned. The changes wrought since the commencement of mountain making were so vast that neither land nor sea corresponded in any way to the previous condition. The life also changed so as to form a great break in its development. This break has not been, and possibly may never be, accounted for. The Mesozoic was the age of reptiles, but there are comparatively few found in the Cenozoic, and mammals replace them. The largest mammal known in the Cretaceous was not larger than a rat, but in the Cenozoic basins, at the very bottom of the strata, are found large mammals, and in the Eocene period they are found of elephantine size. The Cenozoic has been, and probably always will be, known as the age of mammals. In these strata are found the ancestral types of our modern animals, such as the horse, wolves, camels, cats, deer, rhinoceros and monkeys, together with a wonderful fauna that has long been extinct. In Wyoming, the early Cenozoic formations are confined to the basins that were made by the great folds which produced the mountains, such as the Big Horn, Wind River and Owl Creek ranges. Later these become dry and the Cenozoic fresh water lakes extend from the Laramie mountains eastward into Nebraska and Dakota. The sediment deposited was largely clay, sand and shale, which seldom formed a hard rock. Since these beds were deposited after the mountain making, they are unconformable with the Mesozoic, the Mesozoic usually dipping from 10 to 80 degrees and the Cenozoic lying nearly horizontal upon the upturned edges. This great unconformability is the only very marked one in the Rocky Mountain geology above the great unconformability between the Algonkian and Cambrian, and in all cases will serve as a guide to separate the rocks of the Cenozoic and Mesozoic eras.

Another characteristic feature is the almost universal "bad land" topography, typical examples of which can be seen in Goshen Hole, Bates Hole, Big Horn Basin, Green River Basin and north of the Rattlesnake range. The "bad lands" are usually sections almost devoid of vegetation, with narrow, deep gulches, which are often small canons, bounded by great walls that are nearly vertical, and culminating in tower and castle-like formations. Now and then these castellated terraces merge into imaginary crumbling cities and villages and make some of the most fascinating scenery in the state. There are also many places where the water has burst forth from the base of a high bluff and caused a great cavern leading backwards and upwards to open into the soft rock to the surface. These caverns are sometimes two or three hundred feet in length and are large enough to admit a man. They are caused by the water settling on the surface and coming in contact with the sandy formation, causing it to flow like a stream of very soft mud.

Following the Tertiary period of the Cenozoic was the Pleistocene, in which great changes were wrought. The climate of North America, as well as of the Orient, suddenly changed, and great ice sheets commenced to accumulate in the north and move southward. This was the glacial period, and the ice sheet extended as far south in the eastern part of the United States, as the Ohio river, but not nearly so far in the west. These conditions changed everything. The animal life that could not or did not migrate became extinct. The flora and fauna disappeared. Following this period of devastation was one of the retreat of the glaciers and the establishment of modern conditions.

The Cenozoic formations do not enter into any of the artesian basins of the state as important factors; but slight flows of water may be found in them. In many instances Tertiary rocks have completely covered thousands of square miles of earlier strata, which otherwise would have been productive territory. In a few places it will be found advisable to pierce the Tertiary where it is thin and secure artesian water in the earlier rocks. For example, along the south side of the Big Horn range, near Lost Cabin, near Oregon Buttes and in Goshen Hole.

THE TERTIARY PERIOD.

CLASSIFICATION OF WYOMING TERTIARY.

			Thickness of stages in feet.
TERTIARY.	Pliocene?		
	Miocene	Loup Fork	500
	Oligocene	White River	1500?
	Eocene	Bridger	1500?
		Green River	1000
		Wasatch	1000

The Eocene formations of Wyoming are confined chiefly to the Green River, the Wind River and Big Horn basins, which were fresh water lakes during the early and middle Eocene stages. While these lakes were in existence there were Tertiary Eocene seas in which sediments were being deposited, along the southeastern coast of the United States and also along the Pacific Coast region, as well as at numerous other places in the world. The earliest stage of the Eocene which occurs, so far as known, has been found only in New Mexico, and is called the Puerco.

THE WASATCH STAGE.

In Wyoming the Wasatch is the earliest representative of the Eocene and is composed of variegated beds of clay and sand with occasional bands of sandstone. The clays are of a dark red, shading into pink, and in places yellow and brown. The sands are light colored and so soft that a rain storm will cause them to run like a stream of water. This is the lowest Tertiary formation of both the Green River and Big Horn basins, and has a thickness of about 1,000 feet. Estimates have been made that placed the thickness of the Wasatch at from 3,000 to 4,000 feet, but I have been unable to confirm these. This stage is characterized by the remains of many turtles, crocodiles and mammals. Some of the latter were very large, almost of elephantine size, but a description in a brief way would draw out this section to an unreasonable length, since mammals were the dominant life.

THE GREEN RIVER STAGE.

The Green River rocks differ entirely from the Wasatch, and they also differ in the kinds of fossils found. A typical section of the Green River stage is exposed at Green River, on the Union Pacific railroad. The rocks are shales or shaley sandstones capped with a thick band of brown sandstone. The shales are mostly bituminous, and there are bands that contain as high as 45 per cent of gas and oil. In many localities the shales are found in very thin layers, and the bedding has been so perfect that they separate into large plates that are from a quarter of an inch to an inch in thickness. The surfaces of these plates are so smooth that they may some day be of commercial importance. The thickness of this series has also been greatly overestimated by early geologists, and it is more than likely that it does not attain a thickness at any place of over 1,000 feet. Besides being made up of shales, they also have many other peculiarities that will aid in identifying them. These shale beds contain many petrified fish, which are so perfect and remarkable that they are known the world over. The fish are closely related to the modern forms and vary in size from a few inches in length to five and a half feet, and when taken out and properly cleaned, the remains are a mahogany color set upon a slab of creamy white shale. Besides the fish there are found insects, birds, leaves and crocodiles.

It is worthy of special note that no mammalian remains have ever been discovered in this formation.

THE BRIDGER STAGE.

The Bridger stage rests upon the Green River shale and the strata are variegated clays, sands and sandstones. The clays near the base of the stage are a vermillion red and shade into or alternate with lighter colored bands. Toward the top the rocks change into bands of sandstone and clays and often quite thick beds of breccias and conglomerates. It exceeds either of the previous stages in thickness, but absolute measurements are not at hand. The greatest area of Bridger is in southwestern Wyoming, but there are important escarpments in the Wind River basin and Red desert.

The fossils consist of a few fresh-water invertebrates, and monkeys, carnivors, insectivors, ungulates, rodents, birds, turtles, snakes, crocodiles and some large types of mammal life.

The Bridger represents the closing stage of the Eocene in Wyoming, but to the southward and across the Uinta mountains there is yet another stage known as the Uinta, which represents the highest horizon of the Eocene in the mountain region. This group might have covered a portion of southwestern Wyoming during the Miocene and Pliocene times, but was too soft to withstand the great erosion. At the close of the Eocene the basins in which the sediment had been accumulating drained, the Green river draining the southern basin and the Big Horn draining the Big Horn and Wind River basins.

OLIGOCENE STAGE.

There was, however, a great fresh water lake being formed to the eastward of the Laramie mountains and the Black Hills, and in this sediment continued to form.

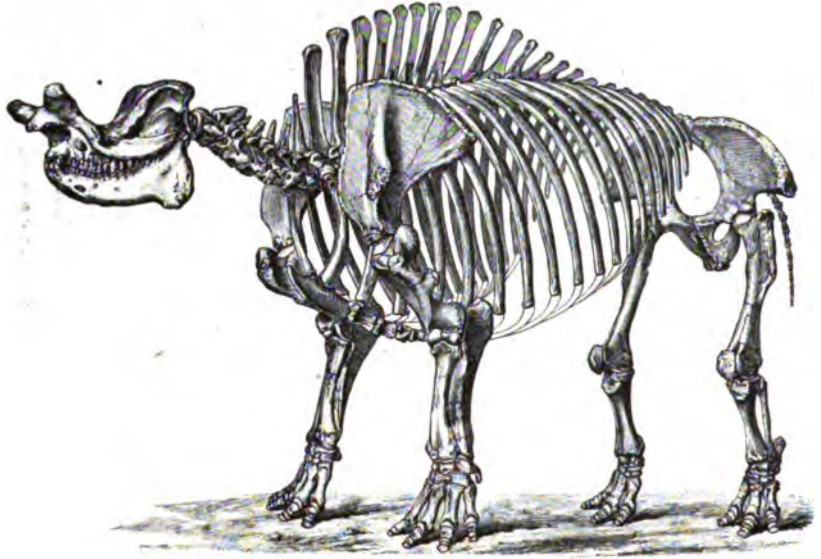
The lowest stage of this lake is known as the Oligocene, and beds are usually called the White River formation. They are largely clays and sands and weather into the typical "bad lands." There are only slight exposures of the Oligocene in Wyoming, since the strata have been covered with Miocene, and unless this covering has been removed the only exposures are found at the base of the Miocene bluffs, where the Oligocene rests upon the Cretaceous. The best exposures are found in Converse county, along the tributaries of the Cheyenne river, and in Bates Hole. The beds vary in thickness from 300 to 500 or more feet. In other localities there are numerous invertebrate fossils and also a flora, but in Wyoming these are absent. The life found in the Oligocene in this state is chiefly mammalian. There were also numerous turtles and a few crocodiles. Carnivorous animals were numerous and were represented by several types, especially cats. The three-toed horses were common. There were many animals that belong to the rodents (gnawing animals). The largest animal was the huge *Titanotherium*, which was herbivorous and nearly as large as an elephant.

THE MIOCENE STAGE.

The Oligocene and Miocene were practically deposited in the same basin, the Miocene representing the last stage in the history of the great fresh lake. The Miocene rocks are chiefly light colored and in southeastern Wyoming they are capped with a thick bed of conglomerate which extends eastward into Nebraska. The strata are quite soft and easily eroded into picturesque columns and spires, which are so well developed in the "band lands." The Miocene rocks have their greatest development east of the Laramie mountains, where they approximate 1,500 feet in thickness. They are also known in the Yellowstone park and in the Saratoga valley.

Life was very abundant. In the Yellowstone park a large flora has been discovered that is very much like the plants of today. Deciduous trees were numerous. Among the mammals which were very common were wolves and tigers of very ferocious types, camels, horses, mastodons, elephants (primitive), and rhinoceroses, the remains of which are common in the Wyoming formation.

PLATE XIII.



Titanotherium robustum, after Marsh. This was an animal of elephantine size that lived in vast numbers in Wyoming during the Oligocene of the Tertiary.

THE PLIOCENE STAGE.

This epoch is, in all probability absent in Wyoming. Early writers referred the beds east of the Laramie mountains to Pliocene, but it is definitely known that these are Miocene.

This was the culminating epoch of the Tertiary and practically introduced the types of animals that we are familiar with today.

THE PLEISTOCENE PERIOD.

The Pleistocene or Quarternary represents recent geological time. Man was probably born on earth at the commencement of this period. The interior fresh water lakes had been drained and elevated during the Pliocene epoch, and Wyoming was no longer composed of high mountain ranges separated by beautiful fresh-water lakes, about which were magnificent forests that were swarming with the greatest variety of mammalian life. Conditions changed when the whole state was elevated some three or four thousand feet, which caused it to become an arid plateau. Our mountain ranges were very different from what they are today, since they were very much higher, probably over 5,000 feet above the present elevations. The valleys were also higher and the great deep canons had not been hewn out of rock.

The commencement of the Pleistocene was marked by the glaciation of the greater part of North America, the great ice sheet extending down to the Ohio river and as far west as eastern Kansas; thence northwest to British America. In Wyoming glaciers existed at the same time, but they were of the Alpine type and did not move down the mountain slopes and fill the large valleys. Glaciers were numerous in the Wind River mountains, the Yellowstone park, the Absaroka, the Shoshone mountains, the Big Horn and Medicine Bow mountains. Glaciers also reached the Wyoming line from the Uinta mountains, in the southwestern part of the state. At present there are a few small remnants of these glaciers in our highest mountains. The glacial period comprised many intervals in the eastern part of the country, but no divisions have been discovered in Wyoming. The first stage of the Pleistocene was one of grinding down the high mountain ranges, of leveling rough country, and the second of covering the rocks with soil, and later by establishing perfect drainage systems and perfecting climatic conditions, which was preparing it for the use of man. During the first part of this period the hairy mammoth and mastodon lived, and with them horses, bison, bears, wolves, tigers and numerous other animals. Not many of the early Pleistocene animals have been found in Wyoming, but no doubt there are vast fields that will yet reward the persevering scientist. The remains of elephants have already been discovered and in some of the caves numerous animals will probably be found that belong to this very period.

This terminates the geological sketch. It has been exceedingly brief, but it is hoped that enough has been said to enable the citizens of this state to decipher, in part at least, the geology about their own homes and to utilize this information in studying the questions pertaining to artesian basins.

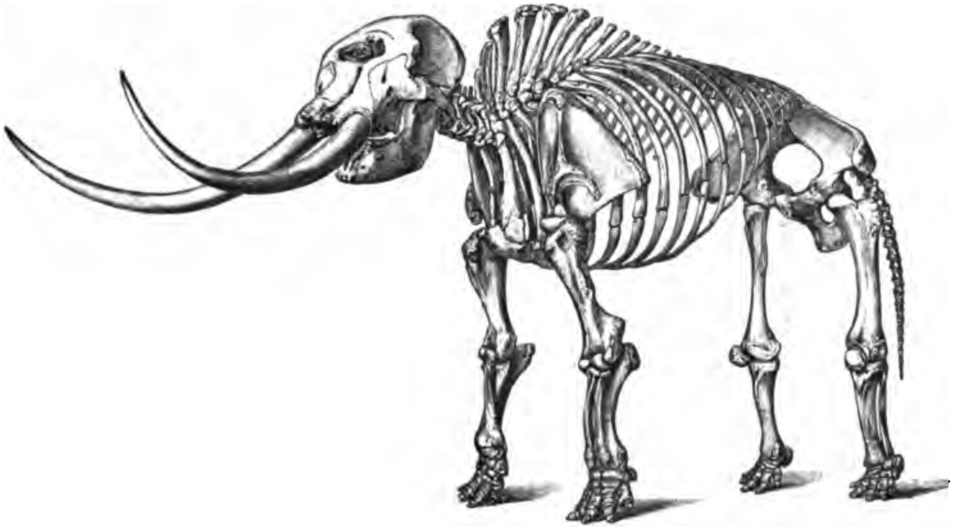
There is one other matter that should be referred to. The lessons taught in the study of geology are indeed many and as a rule they present many interesting phases. In reading or studying geology, consider these few points at least.

This world of ours has not always existed; that it has in some very remote age been created. That originally there was no life on this sphere—that life was born and at the first it was extremely simple; but as geological ages rolled by it became more and more complicated until finally man appeared as the culminating event.

The subject of historical geology deals with the development of life as the records are found in the rocks. In fact, it is the history of the world's development. The history had for its author the Creator and Ruler of this universe—a history written by God Himself, undefiled and undefilable by man.

To those who are interested in the study of geology and wish to perfect themselves in the science, I respectfully refer them to the text-books published by Dana, LeConte and Scott.

PLATE XIV.



Mastodon americanus, Cuvier. The largest mammal that lived during the Pleistocene. Very common in America.

Water-Bearing Zones.

All formations have water-bearing zones under favorable conditions. Drill a well where one will, and at some depth water will be found. The water zones that are to be discussed under this head are the favorable formations in the artesian basins of Wyoming. Sometimes a whole formation contains water, while on the other hand only a single band may be productive. Porous rocks of any kind between two impervious strata form the ideal condition, hence sandstones are often known as water-bearing rocks. Besides being porous, it is necessary for the stratum to have a greater water supply than the rainfall furnishes, in the arid regions, before it can be worthy of consideration In an artesian basin there are two principal ways in which the stratum may gather a water supply. The most important sources are found high up along the ranges, where the precipitation is much in excess of that of the valleys, and where the melting snows constantly feed the stratum so long as the snow lasts. The elevation of the stratum not only provides it with a supply of water, but also furnishes hydrostatic pressure for the wells to be drilled along the foot of the mountain or in the valley. A second source is from the streams that cross the upturned strata. In many instances we will find a good-sized brook in the granitic areas, but by the time the stream has passed oner a few hundred rods of sedimentary rocks, on edge or nearly so, the volume will be found greatly diminished and sometimes it entirely disappears. On account of these conditions the most favorable water-bearing zones will be found in the formations that extend highest up along the mountain slope, unless the rocks are faulted or so eroded as to allow the water to escape near the base of the mountain and prevent storage. There are also other considerations to be taken into account that pertain to the water zones. It is not simply water that is needed, but it must be sufficiently pure to be utilized for town, stock and irrigation. In order to meet these requirements it must not contain much mineral and be comparatively free from sulphur and entirely devoid of petroleum. All of these are associated with wells and springs in Wyoming. A well at Green River contains 24 per cent of sal soda; a spring near Beaver oil basin contains 10 per cent of sal soda; a well on Twin creek flows oil and sulphur water, and many wells at ranches all over the state have had to be abandoned on account of the salts of soda and magnesium. There are a few general rules that can be applied to the water-bearing rocks of Wyoming. The Paleozoic* rocks contain the purest water, and it is always good unless found in the regions where petroleum occurs, or occasionally contains a little common salt. The water is usually hard, since it contains considerable lime. The Paleozoic is also the most desirable since it will be found to furnish the largest flows. In the Mesozoic, waters usually carry large percentages of salts, especially sulphates of sodium, calcium and magnesium. Wells drilled at random in these rocks will as a rule contain inferior water and in many cases it will be found unfit for any use. The choicest bands in the Mesozoic are Triassic and the Dakota of the Cretaceous. The Triassic yields poor water for household purposes when the well receives a water supply from a gypsum bed, but it is in no way detrimental for irrigation. Occasionally a flow of salt water is encountered in the Dakota. Above the Dakota the chances to secure good water diminish, and anyone drilling in any of the Cretaceous rocks from the Benton up should consider that the chances to secure poor water are greater than those to secure good. Especially is this applicable to coal regions. There is, however, most excellent water to be found in the thick bedded sandstone strata of all of the stages. None of these zones will, however, compare in importance with the Paleozoic, since the outcrop is usually along the foot of the mountain and in many instances miles away from the range. This not only lessens the pressure of the water-bearing zones, but on account of the slight rainfall the water supply is also very limited. Occasionally the diminution in the water supply may be augmented by some of the streams issuing from the canons. There is a general rule to follow when considering the production of the various water-producing bands. Cambrian can be considered of greatest importance and from these beds the quantity will gradually diminish as one rises in the geologi-

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*Earlier rocks are not considered under this head.

A Table Showing the Chemical Analyses of Water

Analyses by

Name of Well or Spring	Name of County.	Name of City if Any	Geological Horizon	Silica SiO_2	Oxides of Iron and Aluminum Fe_2O_3 and Al_2O_3	Potassium Chloride K Cl	Sodium Sulphate Na_2SO_4
Davis	Albany		Archæan?	.420	.087		.974
Pelton	Albany		Triassic	1.499	.082		2.612
Rawlins No. 1	Carbon	Rawlins	Carboniferous.	.676	.064	.486	
Rawlins No. 2	Carbon	Rawlins	Carboniferous.	.612	.082	.560	5.452
Laramie Springs	Albany	Laramie	Permian	.507	.233	.111	.233
University	Albany	Laramie	Permian	.950	.047	.210	.373
Filmore		Filmore	Laramie	5.767	.624	1.318	14.124
Experiment Station	Sheridan	Sheridan	Laramie	.881		1.726	29.461
Hot Springs	Carbon	Saratoga	Miocene	7.371	.174	2.414	27.117
Hot Springs	Big Horn	Thermopolis	Triassic	4.986	.227	10.249	15.110
Box Springs	Fremont		Laramie	2.461		1.971	80.849
Genteery	Natrona		Dakota	2.111	.146	.566	48.804
Alkali Spring	Fremont		Eocene	3.324	.111	1.895	723
Hot Springs	Natrona	Alcova	Carboniferous.	2.315	.128	1.464	4.496
Warm Springs	Laramie		Carboniferous.	2.245	.333	.618	4.350
Salt Springs	Weston		Dakota	2.052		3.056	
LithiaWater	Albany	Laramie	Dakota	2.263		1.627	79.333
Bitter Creek	Sweetwater	Bitter Creek	Eocene	.230			25.050
Red Desert	Sweetwater	Red Desert	Eocene	.060			68.250
Carbon	Carbon	Carbon	Laramie?				25.940
Harpers	Albany	Harpers	Fox Hills				49.700
Wamsutter	Sweetwater	Wamsutter	Laramie				54.53
Cherokee Spring	Carbon	Near Rawlins	Archæan?				
Piedmont	Uinta	Piedmont	Eocene				
George	Johnson	Buffalo	Laramie	1.63	.29	1.36	
Experiment Farm	Albany	Laramie	Jurassic	24.64			127.36
Horse Creek	Laramie		Miocene?				

cal scale. Under this rule it is understood that wells are to be drilled near the base of the mountains. In the same way one can estimate the nature of the water, the best being found in the Archæan and up to the close of the Paleozoic. Commencing with the Mesozoic, we know very little about the distribution or chemical character. The information that has thus far been obtained would not make a general rule possible.

It is not always necesary to drill a well to locate a water horizon. Along the mountain slopes these are often indicated by springs. Along the Wind River and Big Horn mountains, springs are numerous in the Paleozoic rocks. It often happens that a spring has its source in a fault, so that the mere fact that water appeared at the surface in any particular band

from Various Geological Formations in Wyoming.

Prof. E. E. Slosson.

Magnesium Sulphate Mg_2SO_4	Calcium Sulphate Ca SO_4	Calcium Carbonate Ca CO_3	Potassium Sulphate K_2SO_4	Sodium Carbonate Na_2CO_3	Magnesium Carbonate. Mg CO_3	Carbonic Acid (free and in bicarbonates). CO_2	Sodium Chloride Na Cl	Magnesium Chloride. Mg Cl_2	Total Solids, grains per gallon	Remarks
		4.496	.152	.117	1.149	.921			8.316	
18.544	19.063	13.676	1.096						56.572	
7.225	23.799	.268					20.644	.208	53.860	
8.800	8.625	7.662					16.101		47.895	
.274		9.951			2.986	3.977	.315		15.587	
.810		6.695			3.855	2.770	1.155		16.865	
		2.344		45.003	.857				70.037	
73.968	67.676	7.791				2.058	.251		183.812	
1.242	11.797	7.226					50.228		107.569	
19.443	13.156	40.454					26.195		129.811	
18.492	11.938	16.480					2.729		134.920	
		.560		17.827	.160	2.700	.624		73.507	
		1.458		164.346	1.848	35.783	75.525		285.013	
17.326	14.217	13.285					27.443		80.674	
2.758		5.954			1.913	1.464	.577		20.212	
50.927	148.373	18.224					890.719	2.279	1115.730	[Li Cl.
50.665	38.739	5.674				1.120	5.796		185.905	Lithium Chloride .688
		.770		48.900			5.590		81.04	Silicate of Soda .50
1.510		4.130		11.970	2.400		2.380		90.70	
11.370	1.700	13.560			1.500		1.480		56.72	Clay 1.17
		3.230		5.140	1.060		1.950		61.47	
		3.130					2.300		59.96	
									12.26	
							226.00		431.00	Alkaline
		3.69		60.59		21.14			90.14	K_2CO_3 .20
40.07	50.48								260.76	
				11666						

would not be sufficient evidence to warrant anyone in calling it a water-bearing zone. Below the mountain slopes the Triassic red sanstones and the Dakota sandstones usually have springs accompanying them.

The Cenozoic will not be considered under this head, since few if any artesian wells will be found in these rocks. So far as investigation has gone, the Tertiary waters are generally impregnated with sodium carbonate and sulphate, which has been found so plentiful as to render them useless for any purpose unless it be for the manufacture of soda.

The following table will give some information as to the general nature of water that may be found in the various geological horizons:

MIOCENE.—As a rule the water is very good. (In Dakota this formation yields very poor water).

OLIGOCENE.—Water contains soda salts and magnesium generally; but good water is found occasionally.

EOCENE.—Very inferior water, salts of soda being the most common; water often alkaline.

LARAMIE.—Water very poor, but often good for irrigation. Sulphur water common, also salts of soda, lime and magnesium. Occasionally good water in thick bands of sandstone.

FOX HILLS.—Both good and bad water, about equally divided.

FORT PIERRE.—Very poor water as a rule.

NIOBRARA.—Good water is found in the chalks; otherwise inferior.

FORT BENTON.—Usually inferior water.

DAKOTA.—Excellent water in the sandstones, usually quite soft. Sometimes brackish. In the oil fields usually sulfurous and otherwise disagreeable.

JURASSIC.—Usually very poor; a few bands of sandstone furnish fair water.

TRIASSIC.—Excellent water except in connection with the beds of gypsum.

PERMIAN AND CARBONIFEROUS.—Excellent hard water, except in the oil districts. Brackish water found at Rawlins.

DEVONIAN.—?

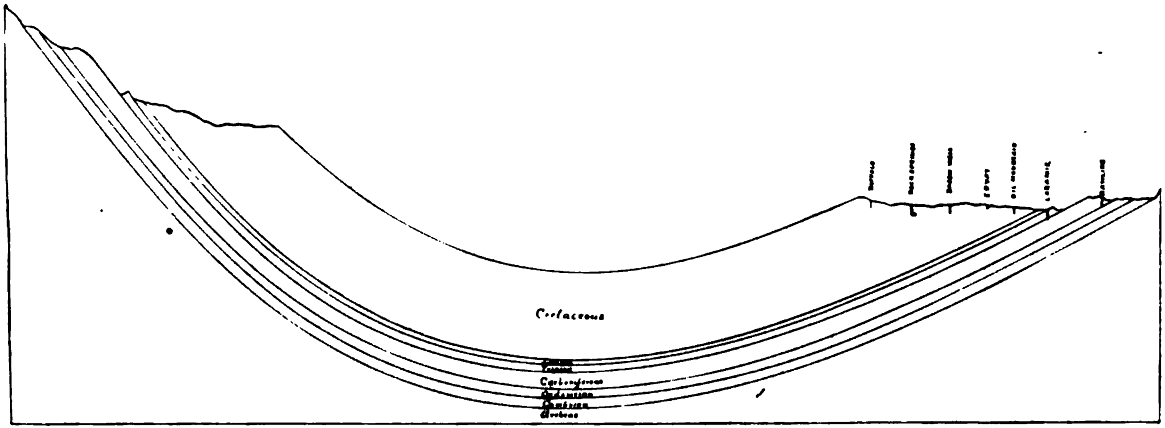
ORDOVICIAN.—Excellent hard water.

CAMBRIAN.—Excellent water. Near the base of the beds usually quite soft.

ALGONKIAN.—Very good water except in mineralized districts. Where the water comes from any great depth it contains various salts.

ARCHÆAN—The purest water found in the state except in mineralized districts.

SECTION I.



Section of an ideal artesian basin in Wyoming, showing the general type and geological position of some of the artesian wells.

Artesian Wells.

The name artesian, as applied to wells today, was derived from the name of French province Artois, where welis of this nature first became famous. In reality, the artesian well is not a modern discovery, for in the old Carthusian convent at Lillers there is a well that has flowed a constant stream since the twelfth century. There are other data which antedates this, and it is probable that flowing wells were known to the Chinese and Egyptians as early as the Christian era.

Originally the word artesian meant flowing wells only; but the meaning has been so broadened in the United States that it includes flowing wells, wells in which the water rises nearly to the surface, and also bore holes that contain water, it matters not how far it is from the surface. Wells that do not flow are not in reality artesian; but much less are those artesian where the water has to be elevated from 50 to 300 feet. The term as used in this bulletin will apply only to flowing wells. In justice to some who have used the word in a broader sense, it may be well to state that wells not flowing have been called negative artesian wells, and those flowing positive artesian wells. The word as used in this bulletin answers the scientific definition of an artesian well, as will be found in all physical geographies and geologies.

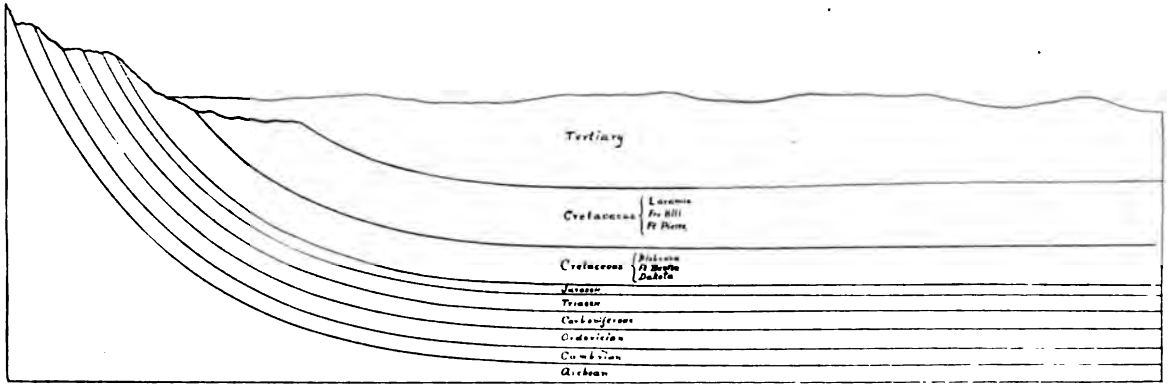
In order to secure an artesian well it is necessary that the strata dip and that they extend above the level of the mouth of the well sufficiently high to furnish a water storage and also hydrostatic pressure. Usually the stratum containing the water is quite porous and is confined between two impermeable strata. In nearly every artesian basin there are numerous water-bearing horizons, all of which may become tributary to a single flow; or they may be brought to the surface in individual pipes. It is not an uncommon thing to secure several kinds of water in drilling a deep well. One stratum may contain an unusual amount of gypsum or sulphuretted hydrogen, which would render it unfit for household use; but would in no way interfere with irrigation. Water of this kind could be brought to the surface in an independent pipe and utilized for irrigation purposes. It often happens that a good flow of hard water is found and just below it a flow of soft water. These can also be separated in the same way. During the last fifty years well drilling has improved in many ways, and especially in sinking deep wells and passing through very soft strata. A century ago a well 500 feet deep was a remarkable one; but at the present time there are wells that are over 6,000 feet deep.

In drilling deep wells a great deal depends upon the nature of the strata.

In Wyoming wells can usually be drilled in the Paleozoic rocks without the use of casing, unless it is put in to shut off a water flow. In the Mesozoic rocks the conditions are entirely different and a driller should be ready to handle a bad cave in any of the formations above the Triassic. In localities where no test wells have been drilled, it will always be advisable to start a large well, if drilling in the Mesozoic strata, so as to allow for casing the caves and to finish with a medium bit. Whenever it is possible, a careful geological section should be made of the strata through which the well is to be drilled. For in this way a driller can locate approximately the soft bands and be prepared to handle caves and also judge of the size of drill to start with to reach a certain zone. In making a section, one should examine the strata in which the well is to be drilled where they are found outcropping along the surface on a mountain slope or in a canyon. In taking measurements for thickness, make due allowance for dip.

It occasionally happens that after a flow has been obtained it suddenly disappears when the drill pierces a porous stratum which does not contain water. Occasionally this may happen when the well is practically finished or that the depth limit

SECTION II.



Section of the type of artesian basins along the eastern flank of the Laramie mountains.

has been reached. In a case of this kind, it is very important that the well be reclaimed if possible. The following suggestions may often prove to be of value. In case the well cannot be drilled deeper, and the flow of water was satisfactory before it was lost, it will be advisable to make a seed bag about the size of the well. The bag is made by sewing up a piece of leather—buckskin is excellent—making a sack that when filled with flaxseed will be about a foot in length. Be sure to make this sack so that when filled it will be small enough to be dropped by means of a rope to the bottom of the well without causing any trouble. Before lowering, have the bag tied, or better, sewed. As soon as the sack is in place it should be packed by lowering the "string of tools" with a cylindrical wooden block in place of a drill and this allowed to fall gently a few times. The flaxseed will swell immediately and in a short time the flow of water will be blocked and it will rise in the well. Several precautions are necessary to do this work successfully. The drill hole in the porous band should not be deeper than the seed bag is long; if deeper, it can be filled with sand or rock. In case a mistake is made with the first a second seed bag can be lowered. As soon as the bottom of the well has been blocked and the water commences to rise a second block can be put in. This should be of Portland cement. The cement should be mixed so that it will pass through a pipe easily. A pipe should be lowered nearly to the bottom of the well—say a foot from it. Then the water should be forced out of the tube by applying air under pressure until the bubbles rise in the well. Then the cement should be allowed to flow into the tube without permitting any air to enter, and the bottom of the well filled to the depth of a foot. This cement will soon harden and make a permanent blocking.

The seed bag will also be found useful in many instances when a flow of very poor water has been found below good water, and it has been found advisable to block the well, rather than attempt to pack with some of the usual packers now in use.

It often happens that a deep well has to be finished with a very small drill and that it is impossible to ream it out after completion. If the water-bearing zone is a solid sandstone or limestone it will be found advisable to shoot the well with dynamite or a little nitro-glycerine. By an explosion of this kind on the bottom of the well a greater surface will be opened up and the flow materially increased. There is one precaution necessary. If the water-bearing zone has been punctured with the drill, and the stratum below happens to be thin, there is a chance that the floor of the water-bearing zone would be fractured, and cause the water to enter a porous, non-water-bearing zone below and never rise to the surface again.

The cost of drilling wells will vary greatly. It has been customary for drillers to charge $2.00 per foot to drill shallow wells, while in the east the cost of drilling deep wells ranges from 40 cents to $2.00 per foot. Wells that can be drilled along lines of railroad in Wyoming should be drilled to a depth of 4,000 feet at a cost of not to exceed $2.00 per foot; understanding that this price does not include casing. When any of the basins in the state become known by drilling wells, the price of drilling will rapidly diminish, for the information obtained by one will in all cases be very beneficial to those who follow, and in the majority of cases the well will not only show the nature of the strata, but also the places where casing is necessary.

There is one danger that will possibly affect more or less the artesian wells in the future. Each basin has a certain capacity and the moment that the tax is greater than the supply all wells securing water from that particular zone in a community will be affected. In some artesian basins in the world the wells have increased in number, until finally none of them would flow at all. Such is the case in the basin near Denver The question of drilling the proper number of wells in any basin is one that should be considered; but there is no law that can in any way regulate it, since each land owner would have equal rights in a case of this kind. All will admit, no doubt, that a basin with 200 flowing wells that would irrigate considerable land would be far superior to 500 that would furnish only enough water for ranch use.

Up to this time, none of the ranchmen in Wyoming seem to have considered the advisability of drilling to secure artesian water for irrigation purposes. The question of water storage has been advocated for several years and a number of small reservoirs have been put in, and a few large ones are being constructed. Nature has already arranged an underground storage of water in many places in the state, and these should be considered before vast sums of money are spent in erecting dams to retain water during flood-tide. Irrigation by means of artesian wells is not a new nor untried scheme. It has met with success in numerous instances, especially in California.

Up to the present time very little attention has been paid to artesian well drilling in this state. There are, however, a few flowing wells, many of which were drilled for oil or in search of oil and gas. In the Laramie basin there are a dozen wells ranging from 100 to 1400 feet in depth, but the majority being less than 300 feet in depth. The wells near Laramie have all been drilled in Triassic sandstone and two or three have penetrated the Permian rocks below. While many of these furnish ample water for a large ranch, none of them could be considered as producing enough for irrigating a small tract of land. With depth, the flow of all of these wells could be greatly increased. For example, the greatest flow of water in the Laramie basin will be found at the base of the Carboniferous in a coarse grit or in contact with the granite. To reach this lower zone, the deep wells would have to be drilled from 600 to 800 feet deeper. The flow of water should be at least ten times what it is at present. At Rawlins conditions are similar. Here the wells are in the Carboniferous and the largest flow will be found in the Cambrian, probably near the granite. The Rawlins wells should be drilled to bed-rock to insure the greatest supply of water. At other places wells have been drilled, but they are usually quite shallow and flow slight streams of water. So long as wells furnish only small supplies of water there will not be any incentive to drill deeper ones. It must be remembered that it will be the deep wells that will furnish large flows, and without these we cannot expect the enthusiasm displayed that would be had a few wells been drilled that would produce a half million or more gallons per day. There is no question in my mind but that the future artesian wells of Wyoming will irrigate large tracts of land and in some instances the pressure will be found sufficient to apply the flow to a water wheel and furnish power to be utilized for any purpose. In South Dakota electric plants and mills are operated by power direct from the wells and the water afterwards utilized for irrigation.

The following table will give a list of the artesian wells that have been drilled in Wyoming, together with such other information that may be of interest:

Name of Well	County	Geological position	Depth	Flow in gallons per 24 hours	Kind of Water
S. W. Downey	Albany .	Triassic. . . .	2—1	3.927	Good
O D. Downey	" .	" . . .	170	8,640	"
S. W. Downey	Carbon .	Fox Hills. . .	380	Small	Poor
Oxford Ranch	Albany .	Permian . . .	540	"	Good
Thomas McHugh	" .	? . . .	112	1,080	"
Thomas McHugh, No. 2 .	" .	? . . .	117	831	"
J. Simpson	" .	Triassic. . . .	112	864	"
G. Montague.	" .	" . . .	150	Small	"
Ryan Bros.	" .	" . . .	85	840	"
Rawlins No 1	Carbon .	Carboniferous	467	108,000	"
Rawlins No. 2	" .	"	486	482,000	Good; brackish
Saratoga.	" .	Tertiary . . .	55	72,000	Good
University	Albany .	Permian . . .	1015	50,000	"
County	" .	" . . .	1470	. . . . . .	"
Judson.	" .	Fox Hills . . .	540	Small	Sulphur; poor
George	" .	Triassic. . . .	140	Quite large	Good

Name of Well	County	City, if any	Geological position	Depth	Flow per 24 hours	Kind of Water
. . . .	Johnson. .	Near Buffalo .	Laramie .	2–1	Small. .	Good
Guthery . . .	Natrona. .	. . . .	Dakota . .	1000	" . .	Sulphur: poor
Rock Springs	Sweetwater	Rock Springs .	Laramie .	. . .	" . .	Poor
. . . .	Natrona. .	Near Frvay . .	Niobrara .	. . .	" . .	"
Bacon	Albany. .	. . . .	Fox Hills .	. . .	Medium	Good
Mullen . . .	Fremont .	Dallas	Permian ?.	1200	"	Oil; sulphur water

INSTRUCTIONS FOR LOCATING ARTESIAN WELLS.

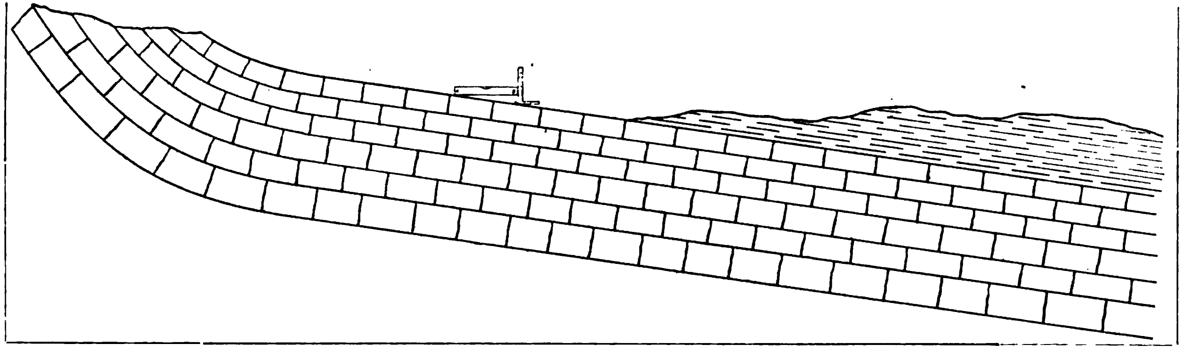
It is not an easy task to locate with assurance an artesian well in a new basin. The many factors entering into work of this kind are so variable that a person may reasonably hesitate in forming an opinion or rendering judgment. Unfortunately it has been the rule to drill regardless of any scientific data that may be at hand. When once an artesian basin has been punctured with a drill and an accurate log kept of the work, those that follow have a comparatively easy task. In advice of this nature it is utterly impossible to make rules that will apply to all cases. It is also impossible to give the necessary information as to the depth of wells and the quantity of water one might reasonably expect.

The location, the geological formation, and the depth of the well all have an important bearing on this subject. A well in one basin 2,000 feet deep might furnish 1,000,000 gallons of water a day, while in another the flow might only be sufficient for one ranch house. Before anyone attempts drilling a well in any of the basins, unless he is fortunate enough to have ample funds to experiment with, let him consider the following essentials:

1. Be sure that you are in an artesian basin and that there are strata above you of sufficient magnitude to warrant a storage of water.

2. Examine the nature of the strata and determine if

SECTION III.



An illustration showing how the dip may be taken with an ordinary level and square.

possible the geological horizon, that you may compare your locality with others, where wells have been drilled. If this cannot be done examine the lithological characters of the strata and satisfy yourself whether they are porous or impermeable and note if at any point you can find springs which would signify an overflow of the basin.

3. Before drilling estimate the thickness of the formations that you will have to drill through and the difference in elevation between the point where the rocks were exposed and the selected place for the well. In order to do this, estimate the dip of the rocks, and use also the thickness in the estimate.

METHOD OF TAKING DIP.

Use a clinometer to measure the dip with, but in case you do not possess one use an ordinary carpenter's level. Select some place along a gulch or canyon where the strata have been worn into a vertical wall and examine carefully until you find the strata dipping toward the site of the well location. At this point place one end of the level on the highest side of a bedding plane and adjust the instrument until it is perfectly level. While being held in this position have an assistant measure accurately the distance from the elevated end of the level downward to the bedding plane. In this way you have data that gives you the dip of the rocks in terms of inches per foot which can easily be converted into feet per mile. Several readings should be taken in an estimate and these averaged. In case the clinometer is used it will be necessary to use trigonometrical formulae to ascertain the number of feet the strata dip per mile. In either case it will be necessary to measure the distance from the point where the dip was taken in a horizontal direction to the well location. This measurement multiplied by the dip in feet or inches per mile will give approximately the depth to drill to reach a certain horizon. From this depth should be subtracted the difference in elevation between the point on the hill where the estimate for dip and thickness were made, and the well.

A Table Giving the Vertical Depths from the Surface for Each One Hundred Feet Measured Horizontally, for all Degrees of Dip Between 1 and 90.

In using this table, multiply the number of feet you have measured horizontally, by the number of feet placed after the degree of the dip you are working with. For example: if the dip of the formation is 12 degrees, and you wish to find out how deep you would have to drill at a point 4,200 feet away, you would have to multiply the 42, which represents the number of hundreds of feet, by 21.25 feet.

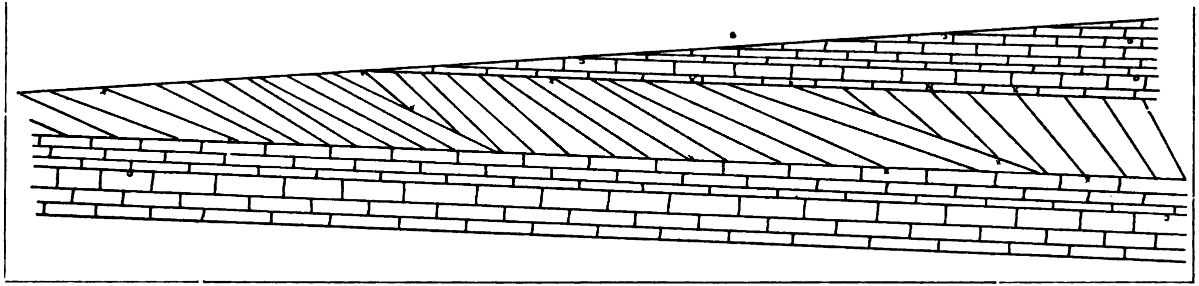
The estimate, made in this way, would be considered as horizontal from the outcropping strata, and from this should be subtracted the difference in elevation.

Degrees of dip	Vertical depth for each 100 feet measured horizontally	Degrees of dip	Vertical depth for each 100 feet measured horizontally
1 degree	1.75 feet	18 degrees	32.35 feet
2 degrees	3.50 feet	19 "	34.50 "
3 "	5.25 "	20 "	36.50 "
4 "	7.00 "	21 "	38.50 "
5 "	8.75 "	22 "	40.00 "
6 "	10.50 "	23 "	42.25 "
7 "	12.50 "	24 "	44.50 "
8 "	14.00 "	25 "	46.75 "
9 "	16.00 "	26 "	47.75 "
10 "	17.50 "	27 "	51.00 "
11 "	19.50 "	28 "	53.25 "
12 "	21.25 "	29 "	55.50 "
13 "	23.25 "	30 "	58.00 "
14 "	25.00 "	31 "	60.25 "
15 "	26.75 "	32 "	62.50 "
16 "	28.50 "	33 "	65.00 "
17 "	30.00 "	34 "	67.50 "

Degrees of dip	Vertical depth for each 100 feet measured horizontally	Degrees of dip	Vertical depth for each 100 feet measured horizontally
35 degrees......	70.00 feet	63 degrees......	200.00 feet
36 “	72.50 “	64 “	205.00 “
37 “	75.25 “	65 “	213.00 “
38 “	78.00 “	66 “	224.00 “
39 “	81.25 “	67 “	235.00 “
40 “	84.00 “	68 “	250.00 “
41 “	87.00 “	69 “	260.00 “
42 “	90.00 “	70 “	275.00 “
43 “	93.00 “	71 “	300.00 “
44 “	96.00 “	72 “	308.00 “
45 “	100.00 “	73 “	327.00 “
46 “	104.00 “	74 “	345.00 “
47 “	107.00 “	75 “	370.00 “
48 “	111.00 “	76 “	400.00 “
49 “	115.00 “	77 “	433.00 “
50 “	119.00 “	78 “	476.00 “
51 “	123.00 “	79 “	515.00 “
52 “	128.00 “	80 “	570.00 “
53 “	133.00 “	81 “	633.00 “
54 “	137.00 “	82 “	714.00 “
55 “	143.00 “	83 “	813.00 “
56 “	150.00 “	84 “	1000.00 “
57 “	154.00 “	85 “	1140.00 “
58 “	161.00 “	86 “	1430.00 “
59 “	166.00 “	87 “	1912.00 “
60 “	172.50 “	88 “	2865.00 “
61 “	180.00 “	89 “	5714.00 “
62 “	188.00 “	90 “	———

In measuring dip greatest care should govern the work and average dip planes considered. In some instances the strata rise and fall in a wave-like structure, which makes an estimate for depth quite uncertain. Special caution should be taken at all times in taking dip, owing to cross-bedding structure of many sandstones, and especially the Triassic. By

SECTION IV.



Ideal illustration of cross-bedding planes. The oblique lines terminating at the letters x are the cross-bedding planes and the less oblique lines marked o are the natural bedding planes.

cross-bedding it is meant that there are appearent bedding planes not conforming to the dip of the strata.

For estimating differences in elevation an aneroid barometer will be found useful; but you must make an allowance for at least twenty-five feet in reading an ordinary instrument. In a case of this kind the reading should be taken at either the top or bottom of the slope and the second one follow as soon as possible, in order to avoid the error that may be caused by a change in the atmospheric pressure. The difference between the two readings gives the approximate difference in elevation.

In case you cannot secure an aneroid barometer, use the same method as recommended for determining the dip of the rocks. Select a place if possible where you can sight from the exposed stratum down to the well location. Arrange a piece of 2x4 on this line, which will represent the average slope of the mountain or hill, and then apply the level and square, which will give you the inches fall per foot, and knowing your horizontal distance you can easily estimate the elevation. It will often happen that one cannot sight the entire distance. Then it will be necessary to take several readings and also horizontal measurements and add the results for entire elevation.

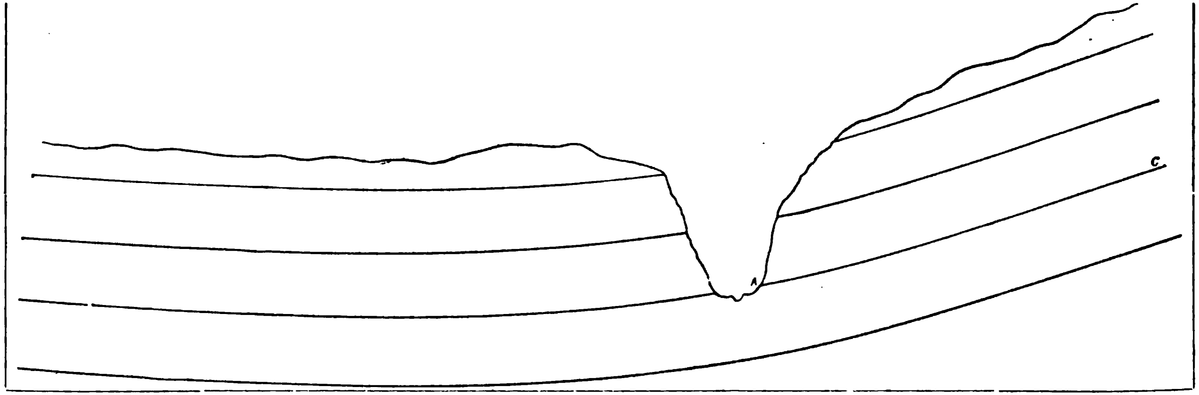
In case a location is being made along a mountain slope be sure that you are not working in a drained area. Such often occur in good basins.

EXAMPLE.

It would be useless to drill for water at any point between A. and C., since the canon that has been cut through the rocks has provided natural drainage for all the strata above the letter A. See Section V.

It will often happen that wells are needed in regions where all of the formations or nearly all are covered with soil, which will almost forbid any preliminary work. However, in case the well is to be drilled in any of the artesian ba-

SECTION V.



An illustration showing how an area in an artesian basin may be entirely drained by a canon paralleling the strike of the formation. Illustration taken from Canon creek, Big Horn county.

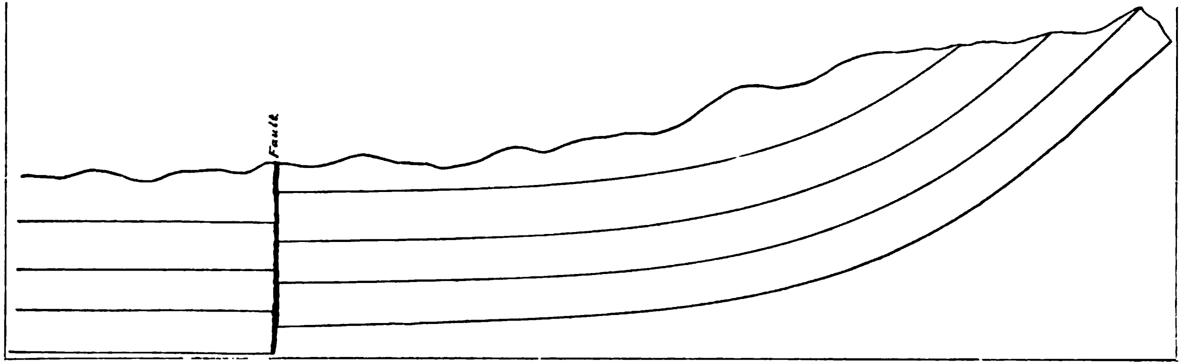
sins, and not too far from the mountains, a flow of water can easily be secured; but the amount depends upon the natural reservoir above, and the nature of the formation in which the well is drilled.

In drilling wells there is but a single point to consider. Hire a first-class man with a first-class drilling outfit. If possible secure a driller who is familiar with the formations. The differences in drilling in the Paleozoic rocks and the Mesozoic are so great that a man will be very successful in the first and fail in the second. The trouble is in the nature of the strata. In the Paleozoic a well can usually be drilled through the formations without being cased. In the Mesozoic the strata are in many places bands of solft clay, marl, and shales that cave easily, and it has in some instances been found necessary to start with a well 18 inches in diameter in order to finish with a three ane one-half inch drill, the difference in size being taken up with casing to hold caving ground.

The question might be naturally asked—why have not working directions been given for each locality? It would have been well to have enlarged upon this topic if there was an accurate geological map of the state, so that one would know from the map the exact formations to be found in each township in Wyoming. As it is, the map that accompanies this bulletin has been made from reconnaissance surveys only, and while the structure is nearly accurate the boundary lines between the formations may vary several miles and in some localities the map will be found to be seriously at fault. For these reasons no detailed directions for any section of land in a region will be attempted. However, at all times the geological department of the University will be pleased to aid in the location of wells and so far as possible make examinations and give directions for drilling artesian wells in any locality in the state.

In some localities where the strata dip sharper than 45

SECTION VI.



An illustration showing how an artesian basin may be partially drained by a fault. Example taken from the Laramie artesian basin.

degrees it will be found to be advantageous to drive a tunnel into the mountain that will cut the sedimentary rocks at right angle to the strike. Tunnels of this kind are not very expensive and they are by far superior to a well. They open a greater area of the water-bearing strata, and by driving drifts at right angle to the main tunnel an immense amount of ground could be opened. Cross-cut tunnels of this kind in mining camps often give rise to a small river.

The Artesian Basins.

THE BIG HORN ARTESIAN BASIN.*

In many respects this is the most promising artesian area in Wyoming; but in this, as in all sections, the most valuable part is covered so deep with sedimentary rocks as to render it unavailable. Being located between two great ranges of mountains, like the Big Horn on the east and the Absaroka and Shoshone on the west, whose highest peaks are above the line of perpetual snow, and whose forest areas are so vast as to store great snow reserves that supply water gradually to these ranges, the water supply is very great. On the south this basin is hemmed in by two cross ranges which meet at the Big Horn river, the western portion being called the Owl Creek range and the eastern, which extends to the Big Horn, is locally known as the Rattlesnake. To the northward this area melts away into the great table lands along the Missouri river in Montana. The formations entering into the structure of these basins are as follows: Cambrian, Ordovician, Devonian, Carboniferous, Permian, all of the Wyoming Mesozoic bands and the Eocene Tertiary. These formations, with the exception of the Eocene, dip gently to the west along the western slope of the Big Horn range and are found resting upon the Archæan at elevations varying from 7,000 to 9,000 feet. As a rule, all of the Mesozoic rocks have been removed from the mountain slopes and are not usually seen until the foot of the mountain is reached, when the Triassic red sandstone usually appears as huge "hog-backs" with precipitous walls facing the range. North of Hyattville some miles the rocks dip at a higher angle and for a considerable distance the Mesozoic rocks are found within a few miles of the Archæan granite. These conditions again change on nearing the Montana line, where the Paleozoic rocks dip gently as they bend about the north end of the Big Horn mountains and form many square miles of exposure corresponding to the southern end of the western slope of the range.

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*That portion of the Big Horn basin lying north of the Stinkingwater river that has been represented on the map as Tertiary, belongs to the Fort Union beds. No Wasatch was observed north of the Stinkingwater river.

In the vicinity of Hyattville there are three local folds. In the one west of Bonanza the exposure is entirely Cretaceous. The one between Bonanza and Hyattville has a Jurassic core and possibly Triassic rocks may be exposed along the axis further to the north. At Hyattville the fold has been nearly obliterated by erosion. All of these folds weaken the head of water stored in the Mesozoic rocks above the Triassic.

Between Hyattville and Red Bank there are numerous springs breaking forth from Carboniferous and Permian limestones, indicating faults, and along Canon creek large areas of Paleozoic rocks have been drained by the deep canons which are parallel to the axis of the Big Horn range in the limestone. North of Shell creek, and extending northwest across the Big Horn river, are two other anticlinal folds, the greater of which has a Carboniferous core and the lesser a Triassic. While these folds have seriously affected the basin along the foot of the Big Horn mountains, they may also be considered as advantageous; for if they are complete arches, that is, not fractured or faulted, they are favorable places to drill and secure flowing wells a considerable distance away from the range. For example, southwest of Bonanza, in the Bonanza oil field, exceptionally large flows may be secured by drilling 2,000 or 3,000 feet. At Hyattville one would not have to drill over 200 feet to reach the same zone in the Triassic sandstone.

Along the eastern side of the Big Horn basin the most desirable territory for well drilling will be found from the crest of the Triassic sandstones toward the mountains. In case wells are drilled in the Triassic, one should drill not less than 2,000 feet. In case shallower wells are desired it will be better to drill in either Carboniferous or Ordovician strata.

Beyond these disturbances, to the westward, the Mesozoic rocks appear, and especially the Cretaceous, which is capped with the Laramie. Westward from the Laramie the Eocene Tertiary covers the entire central area of the basin and extends nearly to the foothills to the west.

On the western edge of the basin the structural features are not so easily worked out. Following the period of mountain making, after the sedimentary rocks had been tilted and eroded, there was a vast accumulation of volcanic breccia deposited for a distance of sixty or eighty miles along the mountains. This has greatly obscured the geology of this region and also hinders materially in the search for artesian water. This great deposit has a width of from ten to forty miles and a maximum thickness of 5,000 or 6,000 feet. Between this deposit and the Tertiary on the east there are exposures of the upper Cretaceous series; but none of the older rocks are known from the Owl Creek range northward until the Stinkingwater river is reached, where there are slight exposures of Paleozoic rocks which extend northward to the Archæan mass on Clark's fork.

In the vicinity of Cedar mountain conditions are quite complicated. This mountain is an anticlinal fold, with probably a Cambrian core, and with the strata highly inclined on either side. To the westward there is a broad synclinal valley that will undoubtedly prove to be valuable artesian territory. On the eastward the strata, although sharply inclined along the mountain, flatten very rapidly toward Cody, which makes the area along the base of Cedar mountain a very fair artesian proposition. Northward, above Chapman's ranch, the opportunities for wells are excellent, but from Clark's fork north to the Montana line the Paleozoic rocks are nearly vertical and the productive area is very narrow unless wells are drilled in the Mesozoic. Along the range from Cody north flowing wells will be found in all of the Mesozoic rock. West of Clark, tunnels may prove to be useful in securing water from the nearly vertical strata.

The structure of the southern end of this basin resembles, to a considerable degree, the eastern border, except that the mountains are not so high. The width of the basin at the southern termination is nearly eighty miles, and artesian conditions extend the entire distance. Along the Owl Creek mountains, including the uplift on the east side of the Big Horn river, the Archæan, so far as known, is only exposed along a portion of the distance. For many miles along the axis of these ranges the Carboniferous or Carboniferous and Permian rocks, form a complete arch that has not been fractured. On this account the extreme eastern and western sides along this border are not as favorable for valuable wells as the central section. The strata dip gently northward from the Archæan rocks along the northern side of the range, and there is an area composed of Cambrian, Ordovician, Carboniferous and Triassic stretching across the end of the basin that varies from ten to twenty miles in width. At no point in this area will it be necessary to drill more than 3,000 feet to reach bedrock, and over the greater portion not over 1,500 feet. The Big Horn river has to some extent drained the strata that lie above the river bed. Near Thermopolis, at the great hot springs, the water rises in numerous places, proving conclusively that there is a very good fountain head. The warm water pouring forth from these springs derives its heat by sinking deep into the earth and coming in contact with heated rocks and being forced to the surface through a fault by means of the pressure derived from the storage of water along the mountains. In this, as in other parts of the basin, artesian wells can be drilled further away from the range, and no doubt they will flow; but the supply of water would be quite limited unless a well could be drilled to five or six thousand feet.

Throughout the central portion of the basin no one will be warranted in drilling wells expecting to secure artesian water. The Eocene formation is usually quite thick and on account of its sandy and clayey texture would foil the most expert well driller before he had reached 1,000 feet.

The most valuable portion of the entire basin extends from Red Bank north to Shell creek; valuable because wells can be drilled to reasonable depths and secure an abundance of very good water.

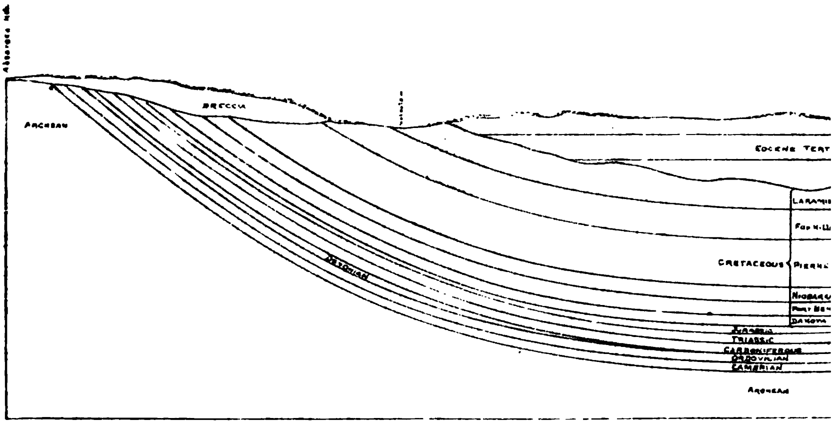
See Section VII for geological structure of Big Horn artesian basin.

THE SHOSHONE ARTESIAN BASIN.

The basin is bounded on the north by the Owl Creek and Big Horn mountains; on the east by the Powder River basin; on the south by the Rattlesnake range and the high bluff of Tertiary extending from the Rattlesnake westward to Beaver creek and the Wind River mountains; on the west by the converging Wind River and Owl Creek ranges. As the limits are given, this basin emerges into the Powder River on the east, and at several intervals along the southern border there are no barriers that would prevent it from extending further southward. The remaining exteriors are, however, valuable territory and will be discussed under separate headings.

The northern border skirts the Owl Creek and the western extension of the Big Horn mountains. This range is continuous and has different names on opposite sides of the Big Horn river, which cuts it in two. These slopes have not been studied and the present observations are based on information secured in crossing these ranges. In the main uplift in the vicinity of the Big Horn river there is a narrow Archæan mass that extends from east to west to an unknown distance, and as plotted on the map is largely guess-work, Mr. J. B. Okie of Lost Cabin having informed me that there was granite north of his place and that it extends westward to the known mass at the Big Horn seems reasonable. The forces producing this great fold that hems in the Big Horn basin on the south operated from the north and caused the sedimentary rocks to dip sharply to the south. This dip gradually decreases to the eastward and westward, to the respective boundaries. South of the Archæan uplift the exposed formations are Cambrian, Ordovician, Carboniferous and Permian(?); south of this all of the Mesozoic rocks are covered with Tertiary. Eastward the Triassic sandstones appear at a distance and will more than likely be found along this uplift. The supply of water will not be large, since this region is wholly dependent upon the precipitation for storage unless it may be possible for some of the porous strata from the Wind River range to augment this supply.

The crest of the Owl Creek range west of the Big Horn river a few miles, with the exception of a few small exposures of Archæan, is all Carboniferous or Permian. Similar conditions exist in the lower Big Horn range east of Lost Cabin. This arch of limestone is very detrimental to the storage of water in the Paleozoic, and unless it is fractured in numerous places, wells drilled to this horizon either eastward or westward from a line extending southward from the termination of the Archæan will be found to be unsatisfactory. Opposite the Archæan, to the south, the Paleozoic rocks are so highly inclined as to make the productive area very narrow, and deep wells will be necessary to reach a flow. About Lost Cabin the Triassic red sandstone seems the most desirable band to penetrate with a drill, though possibly the upper band of the Carboniferous will be found equally valuable. The same can



Geological section from the Absaroka mountains eastward to the cre
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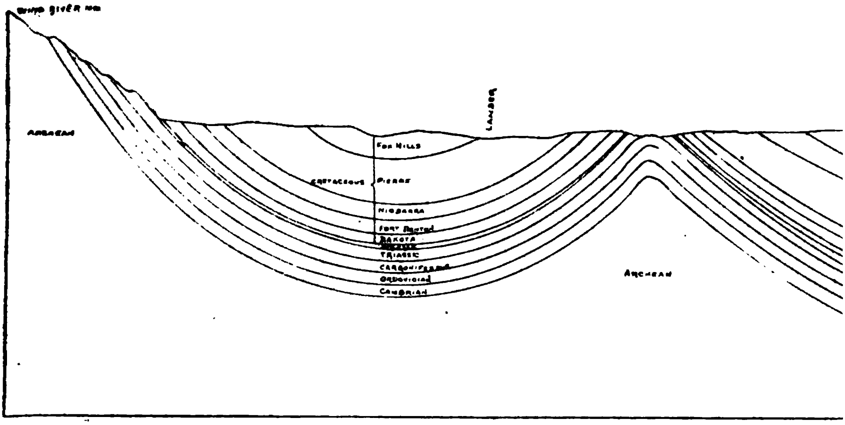

Geological section from the Wind River mountains northeastward to

be said of the western end of the flank of the Owl Creek mountains. Cretaceous strata, whenever exposed, will be found to contain many water horizons, and the best may be expected in the Dakota stage.

Wells may be drilled along the base of this range when there is a thin covering of Tertiary, but a few miles away would carry one beyond the bounds of reasonable well drilling.

There is no question but that there is quite a large basin along the foot of this range for ten or twelve miles, and beyond this the Jurassic rocks appear. Probably there are some Cretaceous exposures along the streams flowing south and west, where the Tertiary capping has been removed. Westward from the river the entire complement of the Mesozoic appears rather suddenly, since it occupies an elevation above the level of the Tertiary.

Since the western boundary of this basin is formed by the convergence of the Wind River and Owl Creek ranges, it will be discussed in connection with the northern and southern boundaries.

The Shoshone anticlinal parallels the Wind River mountains from Hailey nearly to the Big Wind river, a distance of over 50 miles. This fold is some distance from the range, the nearest point being five or six miles from the foot and double that distance from the Archæan rocks. The Triassic strata are exposed nearly the entire length along the axis of this fold. On the northeast the Jurassic and Cretaceous rocks dip away gently and only a few miles distant obtain considerable thickness. On the southwest side of the fold the Jurassic and Cretaceous rocks have suffered greatly from erosion and are seldom seen above the soil surface. This condition produces a long, narrow synclinal basin that lies between the anticlinal fold and the mountains. This can be considered as a small artesian basin. It is to some extent separated from the great basin along the northeast side of the anticlinal. This narrow basin, which gradually widens to the northwest, should be seriously considered by the people who live along this range, as sometimes there is a shortage of water. The possibilities are unsurpassed for large capacity wells, and the Mesozoic rocks are so thin near the range and often in the valleys that wells need not be drilled to great depths. The reasons for this being a specially favorable location are that Paleozoic rocks rise along the flank of the mountains two and three thousand feet above the valley and that the Archæan peaks rise far above the snow line and furnish a constant supply of water during the summer. Above Lander, on the forks of the Popo Agie river, there are places where it will be advisable to tunnel for water. When a tunnel has been completed from the base of the mountain to granite it will be found the bed of a good-sized stream. Excellent places to drill for water are along Red canon, at the experiment farm, and to the north and west along the outcropping Triassic rocks. At Lander and Fort Washakie wells could be obtained, but the depth would be very great. In cases of this kind it would be more advantageous to drill nearer the range and pipe the water to lower horizons.

Along the anticlinal axis wells may also be obtained. Already there is an artesian well near the mouth of Twin creek. This well was drilled to a depth of 1,200 feet. The formations lying beneath the axis of the fold are the Permian, Carboniferous, Ordovician and Cambrian, all of which are supplied with water from the range, and if not exhausted at this point will furnish a supply of water for the country lying beyond the fold to the northeastward. Well drilling to the northeast of the Shoshone anticlinal will have to be confined to a very narrow belt on account of the rapid thickening of the Cretaceous rocks. Beyond these limits no one should drill for the Paleozoic rocks. Wells may be drilled in the Cretaceous strata, but no one should expect more than a slight flow. Those who drill along the anticlinal must always consider that water found will usually be contaminated with oil and sulphur. While it may be possible to utilize such water for irrigation purposes, it would first be necessary to contrive a method to store the oil and allow the water to escape.

From the fold eastward the first distributed rocks are found at the Beaver oil basin, where the Cretaceous rocks stand nearly on edge and there are no associated Paleozoic rocks, since Tertiary has obscured them. Artesian wells can be secured, but the flow will be slight and the water unfit for irrigation, stock or ranch use on account of its contamination with sulphur, oil and alkali.

Eastward from the Beaver basin some five or six miles is the Connant anticlinal, which has a Carboniferous core and the Triassic and Jurassic rocks on either flank. About the base of this uplift the lower beds of the Cretaceous are exposed and wells drilled along these outcroppings will furnish a small supply of water which is very desirable in this very arid region. Here, as at Beaver, one should be prepared to encounter water containing sulphur or petroleum. Petroleum has not been found in this vicinity, but it does occur on both sides, and those drilling must choose well their location, for oil springs are numerous all along the ranges, and wells associated with petroleum would not furnish good water; the oil not being the only drawback, but the presence of an abundance of sodium sulphate being even more serious. Petroleum along the range is wholly confined to the Cretaceous rocks, but ranges from the Dakota to the Fox Hills.

From the Connant anticlinal eastward there is a nearly continuous precipitous wall of Miocene Tertiary that rises several hundred feet from the desert country and practically connects this section with the Rattlesnake mountains. Along the foot of this huge bluff are numerous small springs which have their source in the Tertiary rocks, but there are no conditions warranting well drilling.

Within eight or ten miles of the Rattlesnake mountains there is simply the termination of the Dutton anticinal, known as the Dutton oil basin. In this V shaped area the Triassic rocks are the oldest exposed, and the tilted bands along the anticlinals are so low that there is little or no opportunity for water storage. Along both sides of the fold there are a few small springs, some of which contain very poor water; others are associated with natural gas escapes and a few with petroleum. The conditions in this section are anything but favorable for a large supply of water, and yet I know of no region where water would be of greater benefit.

The Rattlesnake mountains form a peculiar range that is some 40 or 50 miles long and have probably been elevated by a huge fault that extended along the southwestern base. It is not definitely known that there are Archæan* rocks along the southern slope, but there is a complete series of rocks as known in central Wyoming, commencing with the Cambrian and terminating with the Tertiary, along the northern slopes. These rocks dip from 28 to 35 degrees and form great ridges paralleling the range which are occasionally cut by small streams. This range is one of the celebrated oil districts of the state and wells drilled in any of the Cretaceous bands may furnish water that is charged with sodium sulphate, sulfuretted hydrogen, and tainted with oil, since the petroleum ranges from the base of the Dakota stage to the crest of the Fox Hills.

On account of this drawback wells should be commenced in the Triassic and the flow looked for in the lower Triassic or Permian, and possibly in older bands. Along the range from Garfield peak eastward and westward for a distance of from 6 to 10 miles tunneling may be resorted to. Although this range is not high, there is every evidence that wells drilled or tunnels run will afford considerable water. This basin has already been proven, by companies drilling for oil, and at present there are one or two wells flowing very poor water.

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*Only recently, while investigating the Rattlesnake mountains, I found that the Archæan was exposed, and that it is chiefly a hornblende granite.

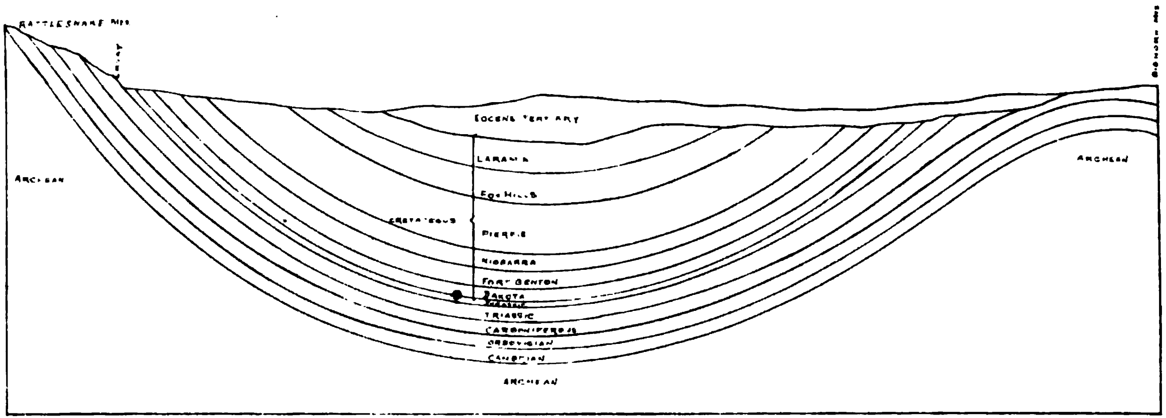
Eastward from the Rattlesnake range there is a broad synclinal valley partially covered with Tertiary rocks, and just beyond the Oil mountain fold. This fold has a Jurassic axis and is badly faulted and can not be considered as an important source for artesian water. Again, the presence of oil impairs its value. On Poison Spider creek, only a mile or two north of Oil mountain, the Guthery oil well has flowed a small stream of sulphurous water for many years. In regions like this, where water is very scarce, small wells like the Guthery may be found advantageous. Other wells drilled to greater depths but further away have not flowed.

See Sections VIII and IX for geological structure of Shoshone artesian basin.

THE POWDER RIVER ARTESIAN BASIN.

This basin includes all of Sheridan, Johnson, Crook, and Weston counties; also the greater portion of Natrona and Converse. In reality it includes nearly one-fourth of the state. On account of some local geological disturbances this, the largest area to be discussed, might have been separated into several small ones; but since the lesser divisions would not be considered as important basins, it has been deemed advisable to include them under one head and pay special attention to the isolated districts. The western limit of this basin is the Big Horn range, with the exception of the depressed area lying between the Big Horn mountains and Oil mountain, where the boundary is the range line between ranges 82 and 83. On the south the Laramie mountains act as a barrier from the big bend of the North Platte river eastward to a point south of Douglas, from whence the line extends eastward to the stae line, over an area that does not offer any artesian

SECTION IX.



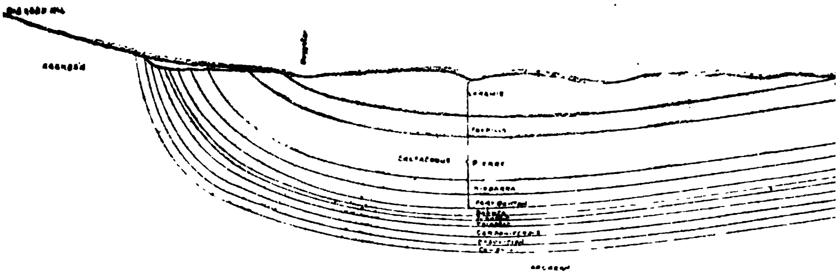
Geological section from the Rattlesnake mountains northeast to the Big Horn mountains, across the Shoshone artesian basin.

[Drawn to Scale.]

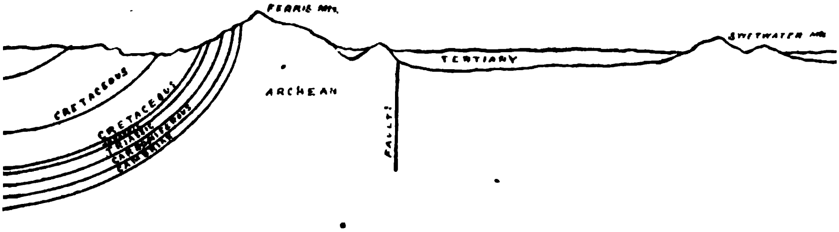
advantages. The eastern limit can be considered the Wyoming line between Nebraska and South Dakota, but since natural law knows no artificial boundaries, the basin from Newcastle south to the southern boundary extends for an unknown distance eastward. From Newcastle northward, the Black Hills uplift forms a natural barrier that contributes to the water supply of Wyoming. On the north, this great basin extends into Montana, but since the Black Hills uplift terminates south of the Montana line, and the Big Horn range practically terminates in Wyoming, that portion north of the Wyoming line is not worthy of consideration, since it is too far removed from the mountain ranges to furnish a water supply, unless wells could be drilled to very great depths, say 10,000 or more feet.

The western side of the basin presents many peculiar conditions, hence it will be necessary to discuss several localities along the range in order to properly understand the possibilities as well as the probabilities of this region. Along the range opposite Sheridan and northward and westward to the termination of the Big Horn range, the strata flanking the mountains gradually decrease in dip. They dip at a high angle at Piney creek and very gently opposite Pass. The formations flanking the range are the same as occur in the Big Horn basin, except that the Devonian is not known, but may be found in very thin bands. As on the western side of these mountains, the strata lie high up along slopes and attain an elevation of from 4,000 to 6,000 feet above Sheridan. This provides for unsurpassed storage, as well as pressure, and makes this section an ideal one for artesian wells. The most desirable locations will be found near the base of the range and extending toward the plains as far as the top of the Triassic sandstone, though at this distance it will often be found impracticable to drill deep enough to reach bed-rock. There are, however, numerous zones between bed-rock and the Triassic that will furnish large flows of water. Beyond the Triassic sandstones artesian flows can be secured almost any place in the valley lands or along the table lands; but the source of the water is in the Cretaceous rocks, and with the exception of the Dakota sandstone the chances are that very inferior water will be obtained. For example, a well a thousand feet deep at Sheridan would in all probability flow; but the water coming from rocks associated with coal is never good. Occasionally water in a coal formation, where there is a heavy band of sandstone between two bands of clay, is excellent. Wells drilled at Sheridan should not be expected to produce much water, since the strata that carry the water beneath the city crop to the surface between Sheridan and the mountains, and in consequence have a very limited water supply. Were it possible to drill deep enough at Sheridan, say 10,000 or 15,000 feet, the supply of water thus obtained would surprise the world.

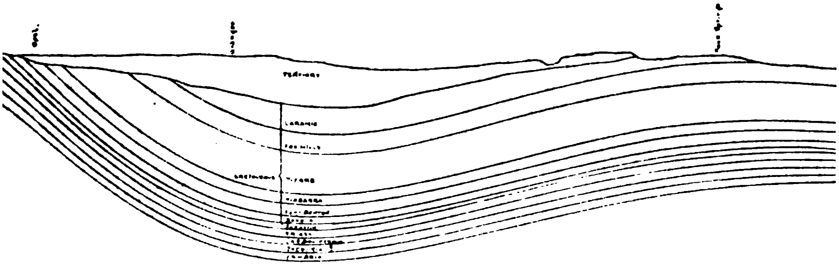
From Piney creek southeast and south the dip of the strata increases very rapidly until at a point opposite Buffalo they are nearly vertical; but southward they again decrease in inclination and at Crazy Woman creek the dip is only 15 or 20 degrees. West of Buffalo nearly all of the sedimentary rocks have been obscured by the detritus from the mountains, which along Clear creek is a very thick band of conglomerate. On account of the strata being nearly in a vertical position it will be impossible for anyone with modern appliances to drill and pierce any of the Paleozoic bands, and it is questionable if any of the lower Mesozoic rocks could be reached. South of Buffalo, as the dip decreases the opportunities for wells increase, and only ten of twelve miles south of Clear creek the territory in which the best wells can be secured has increased sufficiently to warrant large expenditures in drilling. Buffalo is located on the Laramie beds, which dip very slightly to the east. These beds will be found to furnish artesian water, but there will be the same drawbacks to consider as at Sheridan.



Geological section from the crest of the Big Horn mountains eastwa



Geological section from the Ferris mountains northward across



Geological section from Opal eastward through Granger, Rock

Already shallow wells have been drilled at Buffalo that produce small streams of very good water. Deeper wells will furnish more, but the chances are that the water would contain too much mineral matter to be used for domestic purposes or irrigation. From Muddy creek, south of Buffalo, to the southern termination of the Big Horn range, the strata gradually decrease in dip, which widens the Paleozoic outcrops along the range. Along the Big Horn mountains, nearly opposite Mayoworth postoffice, the Archæan rocks no longer appear on the surface, but are covered with a great arch of the Paleozoic, and the Carboniferous rocks form the crest of the range southward to the great bend in the range, and from thence westward. Along the mountain slopes the Triassic rocks are occasionally seen, but as a rule they outcrop at the foot of the range. In this portion of the range conditions are the same as cited in the southern end of the Big Horn basin, which is just across the mountains. Because the granite is covered with Cambrian, Ordovician and Carboniferous bands the storage has been greatly decreased. In case these rocks have been faulted or fractured the water supply would correspond favorably to that portion of the range at Muddy creek. On the other hand, the Triassic sandstone would be the leading horizon and the Dakota sandstone a second one below, but in neither place would the supply be large.

Along the southern boundary of the Powder river basin the Laramie mountains act as a barrier and along these the strata are tilted to the north at various angles depending upon the locality. Here the formations change. The Paleozoic rocks are very much thinner, the Ordovician series have not been detected, and the Cambrian, which has been found along the western arm of the Laramie mountains, thins very rapidly to the eastward. The remaining bands are the same as seen at Buffalo or Sheridan. The Laramie range practically terminates before reaching the North Platte river, which has cut its way across the northern extension through Triassic sandstone. In this vicinity there is a large spring in the Triassic sandstone that acts as an overflow for this section. Eastward along the range the Paleozoic rocks gradually decrease in dip, for many miles. There are in all probability some changes in geological structure along this range that have not been discovered. Between Douglas and Laramie peak there is a small secondary fold with a Triassic core, but with this exception nothing is known out of the regular anticlinal structure. The range is quite low, Laramie peak being only 10,000 feet and the rest of the granite peaks to the westward varying between 8,000 and 9,000 feet. Owing to the precipitous slope along the range opposite Casper, the Paleozoic rocks offer only a very narrow band in which to drill. South of Glenrock the conditions are more favorable, and opposite Douglas the productive area has so increased in width that the artesian possibilities are very promising.

Wells can also be secured by drilling in Mesozoic rocks, but the chance to secure large flows of water decrease very rapidly as one leaves the foot of the mountains. Flows may be secured at Casper, Glenrock and Douglas, but wells are not recommended for these cities: First, since the flow would not be important, and secondly, because the source of the water would probably render it too impure for ordinary uses.

The southeastern corner of the Powder River basin cannot be considered as of importance for artesian well drilling, not that the basin does not exist, but that it is by far too deep to drill and reach the valuable zones. Wells can no doubt be found eastward from Douglas, but the water will seldom if ever rise to the surface. This is largely due to the Tertiary beds of the Miocene period which cover this section and are in nearly horizontal strata. These strata vary from 1,000 to 1,500 feet in thickness. This thickness would have to be drilled through before the Mesozoic rocks that flank the Laramie range on the eastern slopes could be reached. North of Lusk and along the slopes of the Cheyenne river there is a small area of Fort Pierre shales and in this section wells may be drilled deep enough to reach the Dakota sandstone, which would furnish an ample water supply. Further to the northward the Laramie rocks appear and there is little opportunity to drill wells. At Newcastle and northward to Cambria and thence north and northwest, the country favors well drilling and a reasonable water supply may be looked for. This brings us to the region affected by the Black Hills uplift and some lesser folds. While the Black Hills are usually known as belonging to South Dakota, the Wyoming-Dakota line passes over some very prominent peaks of Algonkian schists, in the tin-bearing regions, which leaves a small area in Wyoming. On the western slopes of the Black Hills the Cambrian strata dip very gently westward, and above the Cambrian are the Ordovician, Carboniferous and probably Permian. These are found in rather wide beds, the Permian extending westward to within ten miles of Sundance. From this point westward to Sundance the Triassic red sandstone covers the entire valley, extending to the northward and southward many miles, while the Paleozoic rocks bend to the eastward as they encircle the main uplift. Throughout this area artesian wells can be secured, and although the bands of rock do not reach high up along the hills, one can expect a large supply of water, since the precipitation in this section of the state is almost double that of central Wyoming. North and east of Sundance the conditions are very favorable. The Bear Lodge mountains traverse considerable country north and south. They have a core of Cambrian rocks and the Ordovician, Carboniferous and Permian flank either side. The elevation of the highest peak is 6,750 feet. These rocks furnish water for the western side of the basin, that is supplied from the east by the Black Hills. At Sundance good wells will be secured if drilled to a depth of 1,000 or 2,000 feet. On the west side of the Bear Lodge range is also a second area that will be found productive. Westward on the Belle Fourche river there is an anticlinal fold in Cretaceous rocks, in the Belle Fourche oil field, but this is of little importance for artesian water, on account of a slight production and the contamination with petroleum.

Having dealt with the exterior of this, the largest artesian basin in Wyoming, some may inquire what is to be done with the central region, where streams are scarce and water is so badly needed. Very unfortunately the best water-bearing zones are buried so deep with upper Mesozoic rocks that any attempt to pierce them with a drill would prove futile. In reality this is the most valuable portion of the basin if it were possible to drill and reach the Dakota sandstone or the Paleozoic rocks, but unless there are new inventions that will aid us in drilling, no one need for a moment consider drilling a well deeper than 5,000 or 6,000 feet, and since a well here would have to be from 10,000 to 20,000 feet deep to reach the great water zones, it makes the question hinge on impossibilities. Even in the central regions slight flows may be found near the surface that would repay many times the expense of drilling. In the Salt Creek oil fields artesian water bands have been found, but the water was so saturated with sodium sulphate as to render it useless for any purpose. Along the fold of the Powder River oil basin wells may be found, but if associated with the oil sands they will not be useful. On account of the Dakota sandstones cropping to the surface in this section, there is an excellent opportunity to drill along the axis of the anticlinal fold and secure a large supply of water that would come from the Big Horn mountains. The Oil Mountain oil field should also be included as a possible place for securing a flow. In fact the Guthery well, which is drilled on Poison Spider creek, has furnished a small flow of sulphur water for several years. Wells drilled nearer the axis of the fold should produce more water.

See Section X for geological structure of Powder River artesian basin.

THE GREEN RIVER ARTESIAN BASIN.

The area of this basin is very great, but the boundary lines cannot be surely fixed, since there are no mountain ranges that act as barriers, and also because the Tertiary rocks have obscured the greater portion of the Mesozoic and Paleozoic terranes. The Rawlins uplift marks the eastern limit, but as this only extends a few miles, it only establishes a portion of the boundary. From the Rawlins uplift the line extends south to the western flank of the Sierra Madre range, thence south to the Colorado line. To the northward it extends to Green mountain. The northern boundary extends from Green mountain northwest to South Pass, thence north and west to the great bend of the Green River and thence southwest along the Gros Ventre mountains. The western border is formed by the Gros Ventre mountains and lesser folds that extend southward outcropping occasionally between Lead creek and at a point just west of Opal, thence due south to the Colorado line; but all, or nearly all, of the older sedimentary rocks are buried beneath the Tertiary. The southern boundary is in reality in Colorado, where the Uinta mountains form a higher barrier, with the Paleozoic and Mesozoic rocks dipping toward Wyoming. Conditions about the basin are different from any described. There are some high mountains but the strata do not as a general thing extend high up along the ranges. For miles none of the Mesozoic and Paleozoic rocks are exposed and if they ever did flank the range they have been completely buried by more recent sediment. At Rawlins there is an Archaean exposure, but the sedimentary rocks reach a higher elevation than the granites. To the west of the Archean the Paleozoic rocks, which are Cambrian, Carboniferous and probably Permian dip to the westward at a higher inclination and also gradually decrease in elevation toward the Red desert. The Mesozoic rocks, apparently conformable, dip at a less angle and at a distance of ten or fifteen miles, the Laramie rocks dip only a few degrees to the west. South of Rawlins the dip of the strata gradually flattens, and only the Cretaceous series appear on the surface. Along the Sierra Madre the Cretaceous rocks rest upon the Algonkian schists. The drainage from this range may enter the Cretaceous at various intervals, or it may follow the unconformability to a great depth. North of the Rawlins uplift artesian conditions disappear. The Cretaceous rocks are folded, but form a rough and broken country that is bordered on the west with Eocene Tertiary rocks, and the north by an elevated region known as Green mountain, the structure of which is not definitely known. Possibly Green mountain may act as a storage reservoir, but with this exception there are no elevations to produce hydrostatic pressure. To the west of the Rawlins uplift slight flows may be looked for, and these may be secured many miles west of Rawlins: but large wells should never be expected. Along the Sierra Madre mountains, the question of artesian water cannot be settled without drilling. Surface conditions do not warrant an opinion.

The northern boundary of this basin, from Crook's gap westward, is a broad Tertiary plateau, which practically forms the northern boundary of the Red desert. To the southward the plateau terminates in precipitous bluffs which rise from 500 to 1,000 feet above the desert, and reach in almost an unbroken line from just west of Crook's gap nearly to Pacific Springs. Throughout this entire distance there is no evidence of any rocks older than the horizontal Tertiary strata, that alike covers the table land and the desert. Mesozoic rocks are below; but how deep one would have to drill to reach them no one can tell. Prior to the deposition of the Tertiary, the Cretaceous rocks flanked the Wind River range. These rocks seem to have suffered greatly from erosion along the southern and western slopes and later their upturned edges were entirely buried by the Tertiary. At the foot of the escarpments along the desert it may be possible to drill and reach some of the Cretaceous bands. At present there are no indications to follow, since there are only a few small springs known that have their origin in the Tertiary. From Pacific Springs north and west conditions are similar until within a few miles of the great bend of the Green river, where both Mesozoic and Paleozoic outcrop. These escarpments are very small, however, and give but little promise of important water supplies. West of the Green river, along the southern and eastern slopes of the Gros Ventre mountains, the sedimentary rocks lie high up on the range and offer similar inducements for drilling as have been cited along several of the other important mountain ranges. Conditions are not exactly the same, since the Tertiary strata obscures the most of the Cretaceous and will make it necessary to drill in the lower Mesozoic bands and in the Paleozoic. Along this range the rocks exposed are the same as formed along the eastern slope of the Wind River mountains.

From the Gros Ventre mountains southward to the state line there is an anticlinal fold along which the lowest exposed rocks belong to the Carboniferous. This exposure is not continuous, for the Tertiary rocks have in many instances covered the entire fold. It is especially prominent northward from Opal on the Oregon Short Line railroad. Between the Gros Ventre range and Opal there are no high mountains, and the Carboniferous rocks must be considered the lowest zone in which to look for artesian water, and in this only small flows can be expected. On account of the Tertiary covering most of the Mesozoic the most desirable locations for drilling will be found along a narrow band paralleling the Carboniferous exposure. South of Opal the entire fold is covered with Tertiary, which debars it from artesian possibilities.

The southern boundary of the basin is in reality the Uinta mountains. In Wyoming there is a narrow belt of the uppermost Cretaceous bands that extend from Black's Fork nearly to Dixon. While flowing wells may be found in this region, the locality is unfavorable, on account of coal veins and poor water. Further, the supply would be quite small and if good water could be found the production would not warrant the expense.

Some mention should be made of the central part of this basin. At Salt Wells and to the south there is a broad anticlinal fold which causes the rocks to dip westward to Rock Springs and eastward to Black Buttes. To the east the surface gradually rises so that very little depth is gained. Toward Rock Springs the surface falls rapidly but does not equal the dip. On this account flowing wells can be obtained in the vicinity of Rock Springs and to the north and south some distance. They can be found by drilling at Green River city. None of these localities are recommended: First, on account of the numerous coal veins, which always produce bad water; and second, on account of the abundance of soda salts found in this region. Wells drilled at Green River in which the water rose to the surface and at times flowed, have contained as high as 24 per cent of sal soda or sal soda mixed with other soda salts. Artesian wells have been drilled at Rock Springs, and a small flow obtained; but the water was anything but desirable.

See Section XI for geological structure of Green River artesian basin.

THE SWEETWATER VALLEY.

Since the structure of this valley is very questionable and thus far has not been entirely satisfactorily explained, it can not be called an artesian basin. The valley extends from the North Platte river westward between the Seminoe, Ferris and Green mountains on the south and the Rattlesnake mountains on the north, nearly to Lewiston. All of this area is covered with Tertiary (probably Miocene) except the low round granite masses that have been called the Sweetwater mountains. The largest granite areas extend along the northern side of the Sweetwater river from below Devil's Gate westward nearly to Rongis. The highest peaks are not over 1,000 feet above the valley. The masses are irregular in outline, with numerous low and long narrow ridges extending out into the valley. The slopes are smooth and contain little or no soil, but there are occasional grass patches or a few scrubby pine trees. The peaks are dome shaped and are worn so smooth that it is usually very difficult to scale them. In all cases the Tertiary rocks are found lying upon or against the granite. Besides the large masses of granite there are numerous outliers and these are often very small, only a few acres in extent. These outlying exposures are widely scattered and are to be found not only in the center of the valley but also along the Rattlesnake and Ferris mountains. So far as investigation has proven, there are no Paleozoic or Mesozoic rocks exposed in this region. Along the Ferris mountains the Tertiary was found resting upon the Archæan and across the valley the Rattlesnake mountains so far as known present the same features. Along the Ferris range the Paleozoic dips at high angle to the southward while along the Rattlesnake these rocks dip to the northward. At first one is inclined to consider this valley the axis of a great anticlinal, with the ranges on either side representing what was at one time the base of a broad and high range. On a second thought it seems more likely that this valley was an Archæan land mass and that it continued to be an island from the beginning of the Archæan up to the close of the Eocene Tertiary. Following this period the granite highland was depressed and covered by a Miocene sea, but the peaks and highest ranges protruded above the lake surface. Prior to this valley becoming a Tertiary sea the Ferris and also the Rattlesnake mountains were in all probability elevated by means of enormous faults which paralleled the valley. In case this solution is true the granite peaks of the Sweetwater valley represent the only portions of Wyoming that have been constantly above sea since the beginning of geological time. Again, if this solution is true, the Sweetwater valley is not an artesian basin, and while wells may be found by drilling, no one should expect a flow.

See Section XII for geological structure of the Sweetwater valley.

THE LARAMIE ARTESIAN BASIN.

This ideal basin lies between the Laramie and Medicine Bow mountains, being limited in its southern extension by the union of the Laramie and Medicine Bow mountains and on the north by the westward bend of the Laramie mountains, which forms the eastern boundary, and on the west by the Carbon and Shirley artesian basins, which boundary is a north and south line passing just west of the western termination of the Como anticlinal. In the northern half of the Laramie basin there is a local anticlinal fold extending from the old Miser siding north and east nearly to the Big Laramie river, and a second one north of Rock Creek which has the same strike as the Miser and is several miles in length. West and north of these is the Como anticlinal and a portion of the anticlinal north of Medicine Bow, which influences the strata as much as either of those previously mentioned.

The rocks forming this basin include all of the periods known in the Rocky mountain geology from the Carboniferous to the Fox Hills inclusive. Along the Laramie mountains the Carboniferous and Permian lie high up along the range, often reaching an elevation of from 1,000 to 1,500 feet above the valley and dipping gently, about 12 degrees, to the westward. In reality these rocks form the western slopes of the range and on this account there is not a single stream that forms from springs along the mountain side that reaches the Laramie river, on account of the water following the bedding planes and supplying the artesian basin. The conditions along the southern end of the basin cannot be as clearly shown, since the rocks are badly distorted, faulted, and in many places they dip at a high angle northward and are largely covered with soil. Along the Medicine Bow mountains the dip of the rocks is very sharp, often reaching 60 degrees, and on account of the soil and talus washed from the range they are as a rule buried. In the Centennial valley, which lies between Sheep mountain and the main range, there is a small area in which the rocks are not very thick, since they have suffered exceptional erosion and not less than 10,000. feet of sedimentary rocks have been removed. In consequence the entire strata in this region are not over 4,000 feet thick in the center of the valley and the rocks dip gently from both the east and tne west and likewise from the south. North along the Medicine Bow range the Carboniferous rocks seem to rest upon the Archæan or Algonkian and can be seen occasionally where the streams issue from the mountains. Sometimes they are found higher up than along the Laramie range. The greatest difference between the eastern and western sides of this basin is that on the east the rocks dip gently and the oldest sedimentary rocks extend a long distance from the crest of the range, while along the western side the rocks approach the vertical and are only seen in narrow bands. (For illustration, see geological section of the Laramie basin.)

Along the northern end of the basin the Carboniferous rocks are gently inclined to the south and form a broad band that disappears beneath the Tertiary on nearing Sheep creek. Above the Carboniferous there is a broad band of Triassic sandstone. These gently dipping strata will furnish a considerable amount of water. For this section, the Laramie mountains must be considered as the primary source for the water, which is slightly augmented by the flow from Freezeout hills. The slight uplifts near Miser, Rock Creek, Como and Medicine Bow also affect this whole region. Along the anticlinals the axes have been eroded down to the Triassic and in the one north of Medicine Bow to the Permian or Carboniferous. Between these folds are slight synclinal basins which may prove valuable for small wells. There are a few springs that act as overflows for this section. One is at Como, another at Seven Mile spring, north of Rock Creek, and a third at Boswell springs. These folds have been beneficial to a certain degree, for they have caused the Cretaceous bands to be removed and made it possible to reach the Carboniferous and the Archæan a long distance from the Laramie mountains.

The mountains on three sides of this basin furnish the water supply for this basin. On the plains the average rainfall is about 12 or 14 inches, but in the Medicine Bow mountains it is double if not treble that amount. A considerable portion of this snow, which melting, gradually follows the strata on their downward course and this basin is filled to the overflowing, the overflows being springs in various places along the ranges. Along the foot of the Laramie mountains there are the Laramie, Soldier Creek, Simpson, Red Buttes and Sportsman lake springs, all of which appear to come from a slight fault. The large springs in the Centennial valley are also vents.

The most important water-bearing horizons are the Carboniferous, Permian, Triassic, and Dakota Cretaceous. Above these bands good wells may be secured in which the water will be questionable. Along the western boundary of the basin the above formation cannot be seriously considered, since as a rule they are found high up along the range where water is not needed. Below, along the valley, the depth will be too great to penetrate with a drill. The Centennial valley is an exception to the above, for at any point in the valley it will be possible to drill to the granite. Artesian wells, however, will be found by drilling in the Cretaceous rocks along the Medicine Bow mountains. The chances for securing good water are about equal to the chances for securing poor.

Along the eastern side of the basin conditions are exceptionally favorable for well drilling to secure water in the Carboniferous, Permian and Triassic rocks. There is a belt varying from three to six miles in width the entire length of the basin, where wells drilled from 200 to 3,000 feet can secure good flows of excellent water, the deep wells having preference and producing the largest volume of water.

At the present time numerous experiments have been tried in the Laramie basin and they have usually been successful. Quite a number of wells have been drilled in and about Laramie. These vary in depth from 200 to 1,500 feet and the water has usually been found, but the flow only moderate. It is only fair to remark that had they used larger tools the production of each well would have been increased. So far as known, the wells drilled at Laramie have all been in Triassic sandstone and but a few of them have been drilled deep enough to reach the Permian or Carboniferous rocks, where the best wells will be found. I would suggest that the most valuable water-bearing horizon lies near the granite, where there is a coarse sandstone. At Laramie a well would have to be drilled about 2,000 feet to reach this zone, which in all probability will furnish a surprising water supply. Along the western edge of the basin four wells have been drilled, three of which flow, and in the fourth water would rise to within 18 inches of the surface. The water of two of these wells was excellent. The others were sulphurous and contained considerable sodium sulphate. The good wells secured their flow in the Fox Hills sandstones. The water supply of the Laramie plains can be greatly augmented by drilling artesian wells. The basin is large, has a vast area tributary to supply water which can not only be utilized for ranch and municipal purposes, but to a considerable extent for irrigation. What is most needed today is a deep well that should be drilled a good distance west of the Laramie range and deep enough to reach bed-rock.

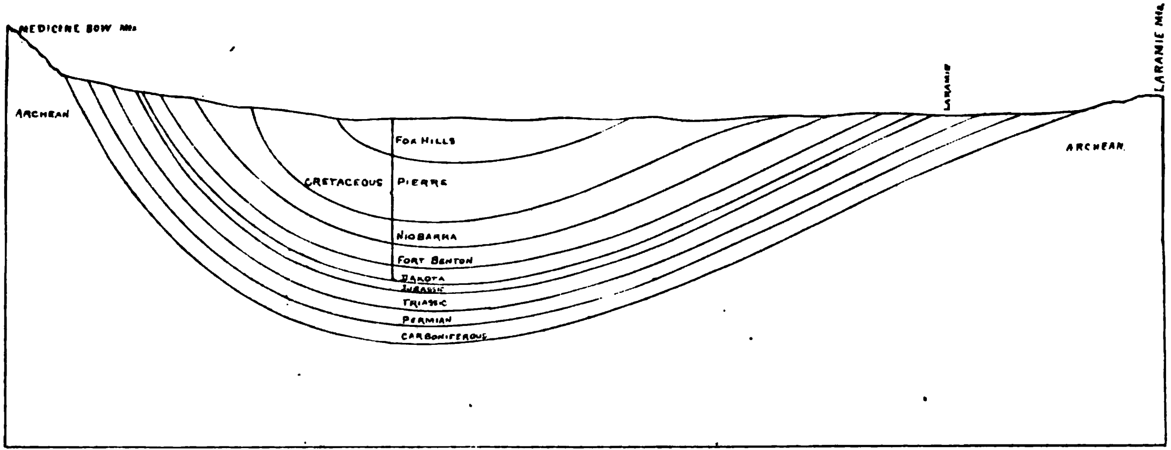
How many wells this basin will support and give to them all a reasonable supply can not be estimated. However, the area is large and the water supply is more than ordinary. By drilling wells the pressure must of necessity be decreased, but this will not be apparent until the demand exceeds the supply.

See Section XIII for geological structure of the Laramie artesian basin.

THE SHIRLEY ARTESIAN BASIN.

Lying east of the North Platte river and north of the Shirley mountains there is a depression that has been known for years as Shirley basin, but this must not be confused with the Shirley artesian basin, which is very much larger. The artesian basin includes all of the territory lying between the Laramie mountains on the north and the Shirley mountains and Freezeout hills on the south. There are no natural barriers hemming in this basin on the east or west. The North Platte river can be considered the western boundary and a line extending north from the eastern termination of the Freezeout hills the eastern. Along the Laramie mountains the Tertiary strata have covered nearly all of the earlier sedimentary rocks. Near the Platte river, where the waters have cut a broad val-

SECTION XIII.



A geological section of the Laramie artesian basin, extending from the Laramie mountains westward through Laramie to the Medicine Bow mountains.

[Drawn to Scale.]

ley, the Tertiary rocks have been entirely removed and exposed the formations from the Archæan upwards. Hence along the river there is a narrow band of exposures which are bordered on either side by Tertiary beds, and which will produce some artesian wells. From a point a few miles below the mouth of the Sweetwater river, where the Platte river surges through the great canon, the sedimentary rocks dip to the north. Passing down the canon one can see along the walls the Cambrian, Carboniferous, Permian, Triassic, Jurassic, and the very base of the Cretaceous, when suddenly the Carboniferous or Permian rocks are duplicated and rise at least 400 feet above the Cretaceous. This sudden change has been due to a fault which extends for a considerable distance on either side of the Platte river and possibly is the southeastern termination of the great fault that produced the Rattlesnake mountains. From this fault flows several warm springs which have been credited with remarkable medicinal properties. The water has a temperature of 140 degrees F. At any point above the fault artesian wells may be drilled and a flow obtained. The Platte river crossing these strata at nearly right angle as it passes through the canon, furnishes them with an unusual supply of water. Below the fault, the Paleozoic rocks are covered with gently dipping Mesozoic bands which are capped with Laramie. Below Alcova ten miles is the axis of a synclinal basin which extends northwest and southeast, beyond which the strata rise gradually toward the Laramie range. On either side of the synclinal basin, that is, near Alcova or near the Laramie range, wells can be drilled in the Triassic and possibly in the Fort Benton and a medium flow obtained. Were it not for the water supply of the Platte river this section would be of no value for artesian water.

From the Platte river eastward* along the range there are

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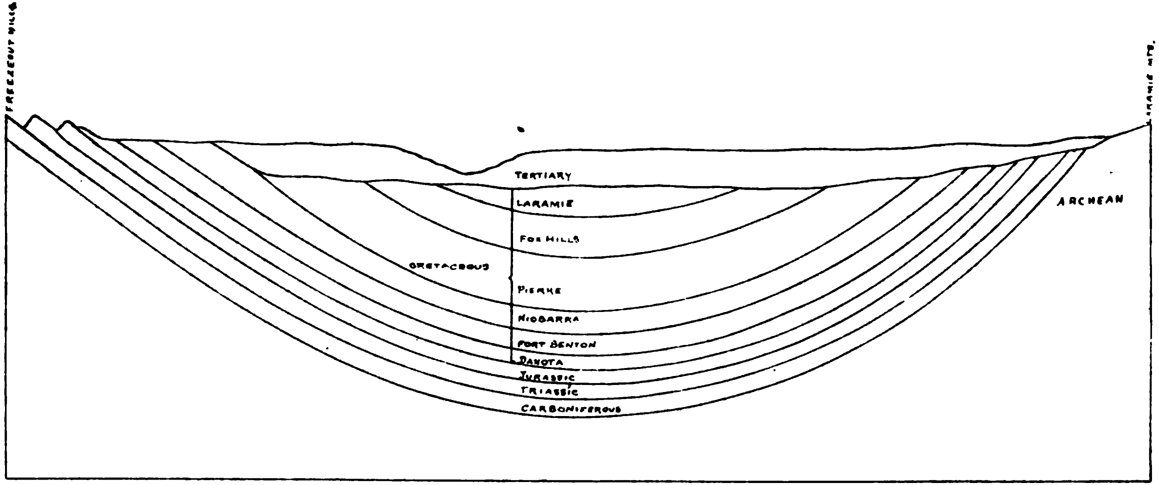
*Since the geological map was drawn I have investigated Bates Hole and found that the central portion of this area has been eroded down to the Cretaceous. The Cretaceous exposure along the Platte river should extend in a narrow belt some thirty miles east and south.

SECTION XIV.



Geological section from the Freezeout hills northeast to the Laramie mountains, across the Shirley artesian basin.

[Drawn to Scale.]

no places where surface indications would warrant anyone in searching for artesian water. Along the Shirley mountains the Tertiary has also covered the upturned sedimentary rocks from the Platte river eastward to the head of Muddy creek. From the head of Muddy creek along the range as far as Freezeout hills, the Paleozoic strata are exposed and are nearly vertical, dipping slightly to the northeast. Below, in the valley, are the Mesozoic rocks, which extend for several miles northward, when they disappear beneath a high Tertiary bluff. All along the range between the last points mentioned, wells may be found by drilling near the mountain base. A better method would be to tunnel for the water in the section.

Along the Freezeout hills the oldest exposed rocks are either Permian or Carboniferous which do not rise to any considerable height above the valley lands. All of the Mesozoic rocks are present and the Dakota band forms the slopes of the hills. These are cut in numerous places by gulches and ravines in which there are a few small springs. By drilling in the Dakota bands and penetrating the Triassic sandstones flowing wells can be obtained. The flow will not be strong and the water may be strongly impregnated with gypsum.

See Section XIV for geological structure of the Shirley artesian basin.

THE CHEYENNE ARTESIAN BASIN.

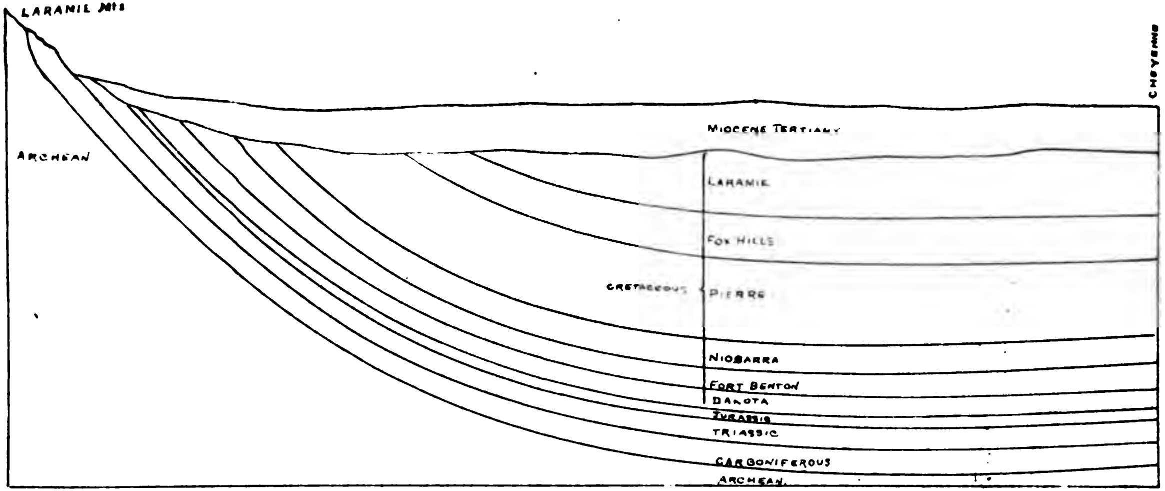
This basin differs from most of the artesian basins of the state. In the first place, the mountains are found along the western side only, the eastern and southern borders having no barrier and the strata extending into Colorado and Nebraska. The Carboniferous rocks exposed to the westward of Cheyenne outcrop at Omaha. Secondly, the water-bearing rocks were originally and are to a great extent at the present time covered with Miocene Tertiary. Nevertheless there are artesian possibilities in the Cheyenne basin, which is bounded on the north by the Powder river basin, on the west by the Laramie mountains, and extending on the south into Colorado and the east into Nebraska. Along the Laramie mountains the Paleozoic rocks, which are composed of simply the Carboniferous or Carboniferous and Permian, stand in nearly a vertical position, except at Table mountain, where a large block of limestone has been carried up by the granite and is an isolated area nearly level. To the northward of Table mountain, along Pole creek, Horse creek and Chugwater, the Carboniferous can be seen as huge hog-backs paralleling the range. Similar exposures are seen south of Table mountain. Occasionally there are exposures of the Triassic sandstone accompanying the Carboniferous and in a few instances the Tertiary has been removed in the valleys, laying bare the Cretaceous rocks as high as the Fort Pierre shales. In localities where the Mesozoic and Paleozoic rocks are exposed and the strata are not vertical, artesian wells may be found, but the water supply will be small, since these strata depend upon the rainfall for their water.

In Goshen hole the Tertiary rocks have been removed from quite large areas, and the Laramie sandstones exposed. Artesian water will be found in this depression, but on account of the coal the water may be very impure. Again, the supply of water from wells drilled in this region will never be very great. North of the Big Laramie river, and especially along the Platte river and extending eastward to the Hartville hills, the geology is entirely different from the southern half of the basin. Here not only the Tertiary rocks have been removed, but also the Mesozoic, leaving the Carboniferous exposures. To the westward of the canon of the Platte there is a synclinal basin, in which there are some Cretaceous rocks. Representing the oldest strata along the Laramie mountains are the Carboniferous and Cambrian rocks extending high up along the mountain slopes. This produces a basin of considerable importance, and wells drilled in the Dakota or lower will unquestionably find an abundance of excellent water. All of the limestone area between the Cheyenne and Northern railroad and Hartville can be considered as artesian territory. Wells will not have to be drilled deep and the flow will not be large. Eastward from Hartville conditions are unfavorable for well drilling. The Tertiary country lying east of Whalen canon will probably never have a flowing well. The rocks to be encountered below the Tertiary are the Laramie, which are quite liable to furnish very inferior water. In case an artesian well is contemplated at Cheyenne in the future they should arrange to drill not less than 4,000 feet. But in any case it is very questionable if a well would ever pay the necessary expense. In this connection it is well to recall some of the wells that have been drilled in the Tertiary that do flow small streams of good water. One of these is south of Cheyenne. In the Tertiary there are lenses of clay that are impermeable layers, and these confine a small quantity of water that is taken up by the ground and carried to lower levels. The Tertiary dip slightly to the eastward, which accounts for the artesian pressure. Small wells may be found near the surface, but since the clay bands are local well drilling will be mere guess-work.

In the Cheyene basin the conditions are such that in the future it may be found advisable to drill wells near the mountains, where they would not be so deep, and pipe the water to lower levels. The great springs at Granite Canon reveal the fact that there is quite a large water storage along the Laramie mountains west of Cheyenne, and that this spring acts as the overflow for the basin.

See Section XV for geological structure of the Cheyenne artesian basin.

SECTION XV.



Geological section from the Laramie mountains eastward through the Cheyenne artesian basin to Cheyenne.

[Drawn to Scale.]

THE CARBON ARTESIAN BASIN.

This basin includes the greater portion of Carbon county. On the west it joins the Sweetwater basin; on the north it is bounded by the Ferris, Seminoe and Shirley mountains and Freezeout hills; on the east by the Laramie basin and on the south by the Sierra Madre and Medicine Bow mountains. The only supply of water that this basin receives from the west is from Rawlins uplift. Along the eastern slops of this anticlinal as far north as Belle springs, artesian water may be found. A large number of wells would greatly decrease the flow, since the uplift is low and only a few miles long.

The city of Rawlins obtains its water supply from the Carboniferous strata. Wells drilled to the eastward of the fold a few miles would also produce water, but it would almost be folly to drill in the Cretaceous rocks on account of the lack of water supply.

Along the Ferris mountains, on the north, the Paleozoic rocks, which include the Cambrian, Carboniferous, and possibly Permian, dip to the southward. At Whiskey Gap the dip is quite sharp, but beyond, toward the Seminoe, these rocks are practically vertical. The soft sandstones of the Triassic outcrop along the foot of the range, and beyond the Triassic there is a complete series of the Jurassic and Cretaceous. No streams of any importance rise along the southern slope of this range. It is a question whether well drilling would be successful along these slopes. It is another case where the rocks are so highly inclined that a tunnel would be more desirable than a well. The range reaches an elevation of 10,000 feet, is partially clothed with forest and would furnish a considerable supply of water.

The Ferris range merges into the Seminoe in the vicinity of Sand Creek canon, beyond which the trend is to the southeast as far as Bradley peak, where it again assumes a southerly course. Between Bradley's peak and Sand creek there are no sedimentary rocks exposed along the slopes and the valleys are covered with sand dunes, which in some places are now accumulating an elevation of over 8,000 feet. Southwest of Bradley's peak the Cretaceous rocks form a long ridge extending many miles and connecting with the Cretaceous rocks farther to the east. In this section the Cretaceous rocks appear to rest unconformably upon the Algonkian schists and consequently would not be a means of carrying water into a basin. From a point south of Bradley's peak eastward to the Platte river conditions change. As soon as the Archæan replaces the Algonkian to the eastward, the Paleozoic rocks are again seen in nearly vertical bands extending high up along the mountains. Paralleling the range on the south side is a secondary anticlinal fold in the Cretaceous rocks. On account of the highly inclined strata along the range, tunnels may be driven for a water supply, in the place of drilling wells. All along the range opposite the Algonkian schists conditions for either wells or a tunnel are unfavorable. The schists are water-bearing in the section and a cross-cut tunnel into Bradley's peak would no doubt yield quite a stream of water. Across the Platte river the Shirley[*] mountains are similar to the eastern end of the Seminoe, except that the dip gradually decreases to the east. Wells may be obtained along the foot of the range at any point between the Platte river and Difficulty creek. What has been said of the northern slope of the Freezeout hills in the Shirley basin is equally applicable to the southern slopes in the Carbon.

The eastern boundary of the basin will not be considered as important territory, since it connects with the Laramie basin on the east. There are, however, numerous places where wells may be drilled with profit. About the termination of the

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[*] Since writing the above I have been in the field and have discovered that the Seminoe is a range entirely separated from the Shirley, and that the Shirley represents an individual uplift. This changes the structure as given in the geological map accompanying this bulletin.

Medicine Bow anticlinal can be considered as valuable territory for small wells.

The southern boundary presents many peculiar phases. The Medicine Bow range rises to a height of over 12,000 feet, but separating it from the Sierra Madre there is a broad valley that has been filled with Tertiary and the Sierra Madre mountains are largey Algonkian, about which nothing older than the Cretaceous rocks have been found. Elk mountain forms the northern termination of the Medicine Bow mountains, and about this very prominent peak are bent the Paleozoic and Mesozoic strata, the Paleozoic lying high up along the slopes and continuing to a considerable distance to the eastward and to the southward. About this mountain there is ample room for many wells, all of which should be large producers. The best flow will be obtained by drilling through the Paleozoic and reaching bed-rock. In the Platte valley, in the vicinity of Saratoga, all of the Mesozoic and Paleozoic strata have been covered with the Tertiary. At Saratoga there is evidence, in the warm springs, which are justly celebrated for their medicinal qualities, that there are some large faults that bring the heated water supply to the surface. It is very probable that the Saratoga valley is a synclinal basin between the two ranges. If this is the case, wells may be found of some importance by drilling through the Tertiary strata at points near the ranges.

The Sierra Madre range presents several features that have not been studied and the country about the base of this range cannot be recommended for artesian wells, but nevertheless a careful investigation might prove it of some importance.

The interior of the Carbon basin is largely made up of the Laramie Cretaceous and cannot be considered as artesian territory on account of the great depth it would be necessary to sink to reach a flowing water zone.

THE UINTA ARTESIAN BASINS.

In Uinta county, south of the Gros Ventre mountains, there are several anticlinal folds that extend south towards the Utah line. For this reason I have used the term basins, instead of basin, for there are several anticlinal folds that will prove to be of some value in securing flowing wells. Unfortunately, much of this area is covered with Tertiary rocks, which seriously interfere with working out the stratigraphical conditions. So far as investigation has gone, there are two prominent anticlinals extending north and south. The axis of the first passes just west of Opal and the second west of Twin Creek. These folds are exposed to some extent along the line of the Union Pacific railroad and also north of the Oregon Short Line railroad. The rocks exposed, so far as known, are the Carboniferous, and these are nearly all north of the Oregon Short Line railroad, and do not form very high ranges. In some instances the axis has been deeply dissected but the Ordovician or Cambrian rocks have not been reported. On account of these sedimentary ranges being low and not accumulating much snow, the basins in this region will not produce large flows Again, on account of the slight elevation of the surrounding country, the pressure will also be insufficient to produce a large flow, provided the water supply is sufficient.

In the country north of Opal, and along the Carboniferous exposures, wells will be found by drilling in the lowest exposures of the Carboniferous or Triassic rocks. Wells obtained in these bands will undoubtedly produce the greatest water supply and will also furnish the most desirable water. Wells drilled in the Jurassic will without question secure water in the Triassic sandstone provided they are drilled to a depth of 500 feet or more. It will also be possible to drill in the Jurassic bands and reach the Carboniferous water supply with deep wells. In no instance can the Cretaceous bands be recommended for artesian wells. They are water-producing and slight flows may be secured in many localities, but as a rule the water supply would not be large enough to supply a large ranch.

South of Opal the conditions are much more unfavorable for well drilling than to the north. The Carboniferous, Triassic and Jurassic bands are entirely covered with the Tertiary. In a few places where the erosion has been very great the Tertiary has been removed and the Cretaceous bands are exposed. The Tertiary covering prevents the accumulation of water in the lower strata and has also made it impossible to drill to the valuable water zones, even if they did carry a large supply of water.

In the vicinity of Hilliard, especially to the eastward, artesian wells can be secured, but the water supply will be very limited and the water very questionable. Along the Bear river slight flows will be found, but there is nothing to warrant any great expense in drilling. There are numerous slight Cretaceous exposures in southern Uinta county, where artesian wells can be drilled, but in no instance should anyone expect to secure a large volume of water.

THE GROS VENTRE ARTESIAN BASIN.

This is a small basin where boundaries have not been traced out on account of the country being very mountainous, forest clad, and having no roads and but few trails. It is also in a region that is well watered and there can never be more than a limited demand for artesian wells. The southern limit of this basin is the Gros Ventre mountains, which rise to a height of 12,000 feet and extend from the big bend of the Green river northwest of Jackson's hole. The eastern boundary is the Wind River mountains, which have furnished a vast accumulation of glacial debris that has buried the sedimentary exposures, or in many instances they have been covered with Tertiary sediments. On the north the structure is only approximately known, but the sedimentary rocks are sufficiently exposed to warrant me in saying that this side of the basin is well supplied with artesian water. On nearing Jackson's hole the valleys and to some extent the high lands are covered with gravel so that the structure is not known. Jackson's hole forms the western boundary and it is very probable that the Archæan exposures along the Teton range were originally covered with Paleozoic rock which dipped to the eastward, but which have been entirely removed by the excessive erosion of Snake river, assisted by glaciers, and their upturned edges buried with the wash from Snake river. The formations entering into the structure of this basin are Cambrian, Ordovician, Devonian, Carboniferous, Triassic, Jurassic, Cretaceous and Tertiary. The Paleozoic rocks are rather steeply inclined to the northeast along the Gros Ventre range and in most instances they are exposed at such an elevation that wells could not be utilized if drilled, on account of the location. In the valley of the south fork of the Gros Ventre river wells may be drilled to some advantage in the Paleozoic. To the west of this tributary the Triassic or some of the other Mesozoic strata would furnish ample water, until within a few miles of the Hole. where the Paleozoic rocks outcrop along the river. Along the eastern side of the basin, wells would not avail anything on account of the country being high and very rough. The same conditions are known along the greater portion of the northern side. In Jackson's hole, the Snake river and its tributaries furnish much more water than can be utilized. There are, however, numerous places in the valley where artesian wells can be secured. Especially are the conditions favorable in the southern end of the Hole in a region that has not been assigned to any basin on account of its being very small. The central portion of the Gros Ventre basin is made up chiefly of high, broken country, much of which has been drained by the deep gulches and canons. The most desirable water zones lie beneath the Dakota sandstones in this as in nearly all of the basins in Wyoming.

THE TETON ARTESIAN BASIN.

This basin lies on the west of the Teton mountains and is in reality tributary to Idaho. The formations entering into its structure, as far as exposed, are largely Paleozoic. The Cambrian, Ordovician and Carboniferous extend up the mountain slopes to perpetual snow. Along this range artesian conditions are ideal, but the demand for artesian water in Wyoming from this source will never amount to anything, since there are abundant streams to provide all the water that the Wyoming area of the Teton will ever need. For this reason the basin has been merely mentioned.

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